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book two

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FINAL

LAKE PHELPS LAKE MANAGEMENT STUDY

BOOK TWO

THE TECHNICAL REPORTS AND APPENDICES

State of North Carolina
Department of Natural Resources and Community Development
Division of Parks and Recreation

March 17, 1980

PREFACE

The information contained in Book Two of the Lake Phelps Lake Management Study represents a compilation of the relevant technical data that provide a scientific foundation for the Lake Phelps Lake Level Management Plan and Final Environmental Impact Statement. It is not intented to be all inclusive, however, the information contained herein represents an acceptable state-of-the-art review of the Lake Phelps social, ecological, and recreational environments.

Noteworthy contents include the edited Task Force Report, a report on the impact of lake level fluctuation on the vegetation of the Phelps Natural Area, and the N.C. State Lakes Regulations. Since the initial preparation of this study, additional data has become available, such as the Lake Phelps Water Release Systems Study engineering report by Pridgeon Consultants, Inc.; the Geology of Lake Phelps by East Carolina University, Information for Nomination of Lake Phelps as an Area of Environmental Concern, and data obtained from the recently installed lake level monitoring staff gauges and graphic water level recorder. For the purposes of an efficient and simplified presentation format, this data which is volumnious at best, is not included in this book. The information, however is on file at the Division of Parks and Recreation administrative office in Raleigh.

FINAL
LAKE PHELPS LAKE MANAGEMENT STUDY

Washington and Tyrrell Counties, North Carolina

* BOOK TWO *

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PART A.

TASK FORCE REPORT

INTRODUCTION

This report, prepared by the N.C. Department of Natural Resources and Community Development's (DNRCD) Intra-agency Task Force on Lake Phelps represents the culmination of a study requested by the Director of the Division of Parks and Recreation. The Task Force was composed of a multi-disciplinary group possessing expertise in a broad range of fields pertinent to the study. The primary objective was to develop a water management policy for Lake Phelps, to be administered by the Division of Parks and Recreation, and have it reflect, as objectively as possible, the management goals for the area and the environmental, social, and economic considerations relevant to the Lake's management.

AREA MANAGEMENT OBJECTIVES

The North Carolina Department of Natural Resources and Community Development, Division of Parks and Recreation considers the following management factors as primary future uses and functions at Pettigrew State Park.

1) Lake Phelps and Pettigrew State Park will continue to be protected, maintained and managed by the Division of Parks and Recreation in an environmentally sound manner, and natural and cultural features will be preserved. It is assumed that suitable habitat for fish and wildlife will be maintained and assured through these measures.

2) Outdoor recreation facilities and programs will be provided as long as the ecological integrity of the lake is not impinged upon. Future recreational use will be increased and expanded within the constraint of integrity. Among those recreation pursuits will be the following:

   Fishing
   Sailing
   Camping
   Hiking
   Nature Study
   Picnicking
   Swimming
   Controlled Boating

3) Pettigrew State Park and Lake Phelps will continued to be available to schools, institutions and others as an ecological resources for scientific study and research when feasible.

4) The Division of Parks and Recreation will continue to cooperate with neighboring landowners towards common goals based on lake-level management.

5) The Division of Parks and Recreation will work closely with the Division of Archives and History (managers of the Somerset House) to assure cooperative complementary activities between the two administrative units.

6) Future expansion, enlargement and development of Pettigrew State Park and other lake contiguous land acreages, will occur to achieve the goals and responsibilities of the Division of Parks and Recreation.

1. NATURAL RESOURCE INVENTORY

1.1 Regional Location. Lake Phelps is an integral part of Pettigrew State Park which is owned by the State of North Carolina and administered by the N.C. Department of Natural Resources and Community Development, Division of Parks and Recreation. The lake covers approximately 16,600 acres which makes it the second largest natural fresh water lake in North Carolina. The majority of the lake lies in Washington County with a small eastern portion falling in Tyrrell County.

The lake proper is connected to the Scuppernong River by a series of canals along its northeastern perimeter. (See Figure A.4 in the appendix).

The canals themselves date back to 1787 and each have water control gates where they enter the lake. The original purpose for the canals was to drain adjacent farmlands between the lake and the river. Also some of the larger canals served as navigational corridors many years ago.

The lake, located in the coastal plain of North Carolina, is recharged principally by natural precipitation with possibly a small fraction coming from underground aquifers. Essentially there is no known overland flow into the lake since it occupies the highest elevation in the area. The lake reaches a maximum depth of about 7 feet near the center, however, its average depth is about 5 feet.

1.2 Topography. A generalized topographic map of the land surface in the entire Albemarle-Pamlico region and specifically Lake Phelps, is illustrated in Figure A.3 in the appendix. The highest elevations approach approximately 20 feet above mean sea level and occur primarily along the western boundary of the region. Eastward there are no perceptible changes in slope except near streams and lakes and around the margins of the area. The general slope of the land surface toward the sound and estuaries ranges from a maximum of approximately 5 feet per mile to a minimum of less than 1 foot per mile. Nearly two-thirds of the area, including most of the eastern portion, is less than 5 feet above sea level.

It should be pointed out that although the name East Dismal Swamp is applied only to the area west of Lake Phelps, the entire area from the Suffolk Scarp to Croatan Sound at the east end of the peninsula is relatively swampy. In fact, those areas less than 5 feet above sea level (which include most of the area east of Lake Phelps) are more swampy than the higher altitude areas to the west to which the name East Dismal Swamp is given.

The elevations (recently established accurately) surrounding Lake Phelps proper range generally between 10 and 15 feet above mean sea level and represent the highest elevations in the immediate area. There are some interesting hydrological features associated with this fact that are discussed elsewhere in this report.

1.3 Geology. The natural resource inventory of an area is never complete without a discussion of the geological structure and history. This is dictated by the fact that the geological materials provide the substrata upon which all plants and animals ultimately depend for support, protection, and nourishment.

The geologic history of The Albemarle-Pamlico region is one of constant ocean recession, advancement and sediment deposition. Basically, there are 12 distinct stratigraphic sequences and thicknesses overlying crystalline basement rocks formed more than 200 million years ago. This igneous base slopes toward the east at a rate of approximately 70 feet per mile. Seven of the 12 layers were deposited during the Cretaceous period (6.5 million years ago) and consists of 2,163 feet of sand, clay, glauconite and limestone beds.

Overlying these deposits are five hydrologically significant layers. The bottommost, or the Beaufort Formation, was deposited during the Paleocene Period (62-65 million years ago). Consisting of 9,120 feet of limestone, sand, and clay beds with a high content of glauconite and shell fragments, this layer forms the principal aquitard for the region.

During the Eocene epoch, 28-52 million years ago, the 187 foot glauconite fossiliferous limestone Castle Hayne Formation was deposited. This formation is the most important hydrologic unit in North Carolina and forms the principal source of water supply in Washington County and the northeastern part of Hyde County. Yields of wells drawing from the Castle Hayne depend on the thickness of the formation penetrated (whereas the average thickness is 187 feet, it ranges in thickness from about 100 feet in Washington County to more than 600 feet in Hyde County). Yields of several hundred liters per minute are readily obtained, and yields of individual wells used to dewater the phosphate mine in Beaufort County exceed 7,571 liters per minute.

The next layer consists of the Pungo River Formation. This formation which is of mid-Miocene Age ranges in depth from 150 feet below sea level in Washington County to 600 feet below sea level in Dare County. Consisting of interbedded sands, limestone, and clay, it also includes a layer of phosphitic materials comprising up to 20 percent of the layers. This Formation is not important as a source of water supply; however, its presence in the region has had a profound effect on water resources in the area south of the Pamlico River where phosphate is mined by the dry, open-pit method which ultimately requires the lowering of ground water levels below this level. The dewatering is accomplished by drawing water through wells from the underlying Castle Hayne limestone.

The Yorktown Formation overlies the Pungo River Formation, and was deposited in late-Miocene times. Ranging in thickness from 150-450 feet, this layer consists of beds of fine to coarse-grained sand and sandy limestone interbedded with clay. The Yorktown is an important source of water supply in the region. Yields of 19-76 liters per minute are common for wells as much as 2 inches in diameter, and yields of 284-378 liters per minute are obtainable from wells with diameters of 6 inches or larger.

The last, or uppermost layer is termed Post Miocene Surficial Deposits, or Quarternary sediments. This unit, which ranges in depth from 40-200 feet consists of interbedded layers and lenses of sand, silt, clay, and mollusk shells. These sediments absorb rain falling on the area and either transmit it down to deeper water bearing zones, or laterally to lakes and streams. Sand layers in the Quarternary sediments serve as a source of water supply to shallow wells throughout the region. Yields of 19-38 liters per minute can be obtained from small-diameter wells screened in this layer.

According to the N.C. Department of Natural Resources and Community Development, Division of Earth Resources, Mineral Resources Section, there are no active mining operations in this region. The nearest commercially important mineral deposit/mining operations occur in Bertie County, approximately 25 miles from the lake.

1.4 SOILS. The topography of Washington, Tyrrell and Hyde Counties is relatively flat with a gentle gradual slope of 5 feet to less than 1 foot per mile to the east. Soils range from thick organic deposits to mineral soils having mixed mineralogy. The organic soils, also referred to as peat or muck, are composed of tree, shrub and vegetation fragments and may be mixed with small amounts of inorganic material. Mineral soils contain varying amounts of sand, silt, and clay sized material generally containing quartz, feldspars, heavy minerals and layer silicates.

1.5 VEGETATION. At the time of the preparation of the original task force report, there had been little definitive professional biological research conducted on the Pamlimarle peninsula. However, since that time, and during the preparation of the Pettigrew State Park Master Plan, a comprehensive vegetative analysis has been completed. The following section is abstracted from that master plan.

"Evergreen Shrub Community: The low elevation, high water table, and poor drainage of the soil causes the growth of peat in the Lake Phelps watershed. Peat is defined as partly decayed, moisture-absorbing plant matter found in bogs and swamps. These areas extend around the entire northern, western, and southern portions of the lake, and are commonly called pocosins, bays, or evergreen shrub bogs. The mild climate of hot summers and short mild winters causes the shrubs to retain their leaves throughout the winter, and the evergreen dominance is insured by their ability to withstand long periods of water-saturated soil.

This community is usually typified by an open canopy of pond or loblolly pine. The dominant shrubby species which form an impenetrable jungle of undergrowth include sweet bay, red bay, and loblolly bay. Less important shrubby species include titi, fetter-bush, sweet gallberry, inkberry, pepper bush, and sheepkill.

Fire is another factor controlling the vegetational dominance of the pocosin. If there is frequent fire damage and the water table is lowered either by reduced precipitation or increased drainage, the vegetation remains in cane. This situation occurs at several points on the southeastern shore of the lake, and covers less than 100 acres. Other species found in the cane-pocosin include pepper bush, loblolly bay, and sweet gallberry.

Bald Cypress Forest: There is an area on the north and northeastern shore of Lake Phelps that does not consist of peat or muck. The soils range from the Wysocking silt loam to the Pasquotank and Hyde silt loam at Somerset Place. Bald cypress dominates this low, wet area along the lake. The Somerset Plantation house, built in the early 1800's, was constructed of cypress, so the largest trees are at least that old, possibly even 300 years old. This stand is largely undisturbed, with apparent logging only in the proximity of the house.

The lake itself represents the deeper portions of the Pleistocene sound which covered much of eastern North Carolina. Evidence that the level of the lake has fluctuated in the past is reflected in the interbedding of the sediments, as well as in the plant life along the shore. This is particularly apparent from the distinct size classes of cypress, which may indicate that the level changes have been periodically extreme, rather than gradual.

The water level must have been higher at one time, as suggested by the presence of cypress knees quite distant from the shore. This is a common occurrence when the trees are in standing water for an extended period of time. The level must have also been lower to allow the cypress and black gum, presently standing in the water, to germinate. A number of cypresses have germinated where silt and organic matter collected along the fringe of the lake. The two factors that have been primarily responsible for the level fluctuations are the gradual natural process of lake filling, as well as water level control by canal flood gates.

As the elevation and the distance from shore increase, the cypress on the higher and drier areas are eventually overtaken by other canopy species. Therefore, the cypress-gum zone at the water's edge is replaced by tulip poplar and sweet gum where the drainage is better. The stand appears to be at climax for the present water level, as indicated by the number of seedlings. However, if the lake is drastically drained, these other canopy species will soon dominate. On the other hand, if the level of the lake is increased, the cypress forest will submerge, perhaps eliminating the understory species.

The western portion of this forest is a better representation of a natural swamp with typical swamp species, and the more extensive cypress stand. There are no aquatic species present, possibly because of wave motion along the shore. However, several aquatics, such as parrot feather, pickerelweed and eelgrass, are present at the eastern end, where it is perhaps more protected against wave action. Behind the aquatic zone is a narrow rush zone, and a shrub zone with buttonbush, elderberry and beauty berry as representative species. The understory beneath the cypress is well developed, dominated by paw paw, Virginia willow and spicebush.

Bog and pocosin species such as sweet peperbush, sweet bay, and red bay are present in the acidic, fine-sand and peat soils. Abundant herbaceous species are Jack-in-the-pulpit, marsh pennywort, jewelweed, clearweed, and false nettle, as well as several species of ferns. These are entangled by a number of species of vines, limiting comfortable access to the area.

Other herbaceous species have invaded openings where trees have fallen, and along the old carriage road. Local residents have apparently cleared shrubs and vines from a small segment of the natural area to promote better air circulation around the lake.

This cypress swamp is a unique area and should remain as it is, providing the water level of the lake is not altered significantly. In its natural state, it would serve as an excellent scientific study area, and for this reason is under consideration for inclusion in the Natural Area System of the North Carolina Division of Parks and Recreation." (Schweitzer and Williams, 1977).

1.6 FIRE PROBLEM. The Lake Phelps area has a history of severe forest fires. In recent years this problem has been most severe in the areas south and east of Lake Phelps. From a forest protection standpoint, the problem has been somewhat reduced during the past few years by the large acreage being placed into cultivation.

Even though forest fires in the Lake Phelps area are not the problem they have been in the past, numerous fires still occur on cultivated and semi-cleared land. This problem is compounded by the nature of the soil and the practice of using fire to dispose of debris resulting from land clearing. The entire area south and east of the lake is composed of deep organic soil which is in the process of being extensively drained for agricultural purposes. Once drained, during periods of drought, fires may burn for months and consume organic soil to a depth of several feet. On cultivated land probably the greatest loss is the loss of the soil itself. The removal of organic soil by fire results in the exposure of underground wood which requires the land to be cleared again before it can be cultivated.

Burning permits are required before burning debris resulting from land clearing activities. The Division of Forest Resources has the authority to refuse to issue a permit if, in the opinion of the issuing officer, fire is likely to escape to the woods. Permits are not issued during periods of severe drought. However, piled debris mixed with organic soil may burn for months creating fire hazards and pollution problems once ignited. During drought conditions, arson and accidental fires from cigarettes and sparks from farm equipment are common.

Most of the accidental fires occur during periods of extreme drought. During these periods the water level in the drainage canals is normally very low and adequate water for fire suppression purposes may not be available in sufficient amounts to extinguish large areas of burning organic soil. The most practical means of extinguishing large areas of burning organic soil is to flood the entire area. Water in sufficient amounts for this purpose could be obtained from numerous deep wells. However, the most economic source of water is no doubt from Lake Phelps. The low water table problem can be somewhat elevated by the installation of water control devices at strategic locations. A water control system will be required before any appreciable area can be flooded regardless of the source of the water to be used.

The design of the road system in the deep organic soil areas, which can serve as a system of dikes, lends itself to flooding blocks of land one mile by one half mile or approximately 320 acres. The canals can provide a ready access route to move water from the available source to the location where it is needed.

Water, in a sufficient amount to flood large areas of burning organic soil could be moved from Lake Phelps through the use of specialized volume lift pumps. This could be done without digging canals into the lake. It can be accomplished by moving the water through large rubber tubings from the pumps to existing canals in conjunction with the installation of a water control system. It is believed that this method would be more economical than any other means of obtaining water to flood large areas of burning organic soil.

Burning organic soil can produce a severe air pollution problem as well. In the past, it has contributed to numerous automobile accidents in the area, and is always a source of numerous citizen complaints. It also results in the loss of crops and a large cost in re-clearing burned over land. Use of water from Lake Phelps to help solve this problem will be taken into consideration in any water use plans for Lake Phelps. However, no land flooding plan will be established until a thorough feasibility study regarding the use of the canals for fire extinguishing has been made.

1.7 WILDLIFE

1.7.1 INLAND FISHERY RESOURCES AT LAKE PHELPS. Lake Phelps contains an excellent fish population. Samples collected by DNRCD biologists have indicated the population is well balanced. Ratios between the numbers of game and forage species has always been found to be within suitable bounds. The primary game species present are largemouth bass, white perch, bluegill, and chain pickerel. Substantial populations of two desirable non-game species, channel and white catfish, are also found in the lake. An additional non-game species often collected in significant numbers has been the longnose gar. Two anadromous species, alewife and blueback herring, have been present in many of the samples, indicating that their intermittent access into the lake in the past has resulted in a contribution to the forage base. Other forage species that have been represented in various samples are large numbers of golden shiners, tidewater silversides, gizzard shad, and striped killifish. The presence of striped killifish and tidewater silversides serves to further document the past movement of fish into the lake via the canal system.

An open water sample collected with a fish toxicant in October, 1955 yielded alewives and yellow perch. Near-shore samples contained bluegill, banded killifish, swallowtail shiners, and alewives in abundant numbers. Also captured were green sunfish, American eel, white perch, channel catfish, and largemouth bass. At that time, sportsmen of the area reported good to excellent fishing for largemouth bass throughout the summer and fall of 1955.

Two standard gill nets and one standard trammel net were set in the lake in June, 1965 over a four-day period. The most abundant game species captured was the white perch, with other game species including largemouth bass, yellow perch, pumpkinseed, bluegill, and chain pickerel. The most abundant non-game species collected were the longnose gar and alewife. Golden shiners, tidewater silversides, blueback herring, tadpole madtoms, channel catfish, gizzard shad, and striped killifish were also collected. A fish toxicant sample in 1965 included juvenile alewife and blueback herring. Sportsmen again reported excellent fishing for largemouth bass, white perch, channel catfish, and bluegill.

1.7.2 FISHERY RESOURCES OF THE SCUPPERNONG RIVER SYSTEM. The Scuppernong River is approximately 27 miles in length and originates from swamps located in Tyrrell County and flows in a general northly course. Just below its origin the total water volume of the river is augumented by the additional flows of water from a number of canals that lead to Lake Phelps.

A stream survey of the Scuppernong River basin was conducted by Wildlife Resources Commission personnel in 1965. The survey presented information regarding the physical and chemical characteristics and biological characteristics of the river and its tributaries (both natural and man-made). Most of the information concerning fish populations concentrated on the various species of game or sport fish found in the area with no mention of important commercial species and related commercial operations of the area. However, the Scuppernong River has supported a significant commercial pound net fishery for river herring (blueback herring and alewife) for many years. Approximately 50 nets have been fished manually in the river during recent years, however, the catch has declined from over 1,000,000 pounds in 1965 to less than 100,000 pounds in 1976. Reliable catch information, prior to 1965, cannot be found. In addition, a significant recreational dip net fishery for river herring (estimated at no less than several thousand pounds) takes place every spring along the canals and in the vicinity of Lake Phelp's water control structures. More than 500 fisherman visits are involved in this activity annually.

In addition to river herring, occasional striped bass, American shad, catfish, white perch, flounder, and gizzard shad are taken in the pound nets and gill nets placed in the lower part of the river. Important game fish taken from the area include largemouth bass, sunfish, and crappie as reported by the N.C. Wildlife Resources Commission.

1.7.3 WATERFOWL. Ducks and Canada geese are the most common forms of wildlife which utilize Lake Phelps. Although their numbers are not unusually great, the lake is considered to be an important wintering and nesting area. During the last ten years, the total waterfowl population during the time of the annual mid-winter aerial census has ranged from 590 to 4,000 birds. Canada geese comprise a major proportion of these totals. Their numbers, during this 10-year period, have ranged from 220 to 3,100 individuals. These numbers represent the populations present at a particular moment in time; peak populations of given species undoubtedly exceed these census figures, however, these data are not available. (Please note the Appendix, Page A.33 for a mid-winter water fowl inventory.)

Lake Phelps serves primarily as a waterfowl nesting area and sanctuary during the wintering period. The Canada geese and many of the dabbling ducks move out to the adjacent agricultural areas and swampy areas to feed on waste grains and natural foods. The diving ducks, coots, mergansers and some of the dabbling ducks utilize the natural plant and animal foods which occur in the lake and along the shoreline.

1.7.4 BIG GAME. The black bear, although now present in a fewer number than a decade ago, still occurs in the heavily wooded areas adjacent to Lake Phelps. It frequents the shoreline areas but is not directly dependent on the lake proper for survival. Hunting for bears is not allowed in Washington County at the present time.

White-tail deer are unusually abundant in the vicinity of the lake, and utilize the wooded areas for both cover and feeding. Supplementary food supplies are readily available in the form of agricultural crops, particularly corn and soybeans. The lake proper offers little in the way of food for deer, however, its presence is vitally important as an escape area from hunting dogs and hunters and from free-ranging dogs during the fawning season.

1.7.5 SMALL GAME AND FURBEARERS. Quail, mourning dove, woodcock, rabbits, and gray squirrel are common small game species found in crop lands and woodlands in the vicinity of the lake.

The prominent furbearing species include raccoon, opossum, mink, muskrat, fox and bobcat. Of these species only the muskrat and raccoon are dependent upon the lake proper to any significant degree; all, however, utilize the heavily wooded areas which occur along the shoreline.

The swamp and brushy habitats along the shore support a great variety of non-consumptive forms of wildlife, including birds, mammals, reptiles and amphibians. The osprey, great blue heron and kingfisher occur, as well as a variety of other wading birds and song birds.

1.7.6 RARE AND ENDANGERED SPECIES. No representatives which are currently on the state or federal rare and endangered species lists are known to be endemic to Lake Phelps or its immediate environs. However, the bald eagle which is occasionally found in Pettigrew State Park, is listed by the Interagency Wildlife Coordination Section within the North Carolina Wildlife Resources Commission as an endangered species. An eagle sighting was recorded in February and April of 1973 in Washington County. Two other endangered species that have been thought to occur in Pettigrew State Park are the venus fly trap and the American peregrine falcon. There are no confirmed records of the red-cockaded woodpecker or the American alligator.

1.8 AESTHETICS. Pettigrew State Park possesses both cultural and natural aesthetic appeal, making it one of North Carolina's most interesting State Parks.

Lake Phelps occupies 16,600 acres of the 17,360 acres in Pettigrew State Park along with the Somerset Place State Historical Site. The lake represents the second largest natural lake in North Carolina and is primarily recognized for its largemouth bass fishing and natural amenities.

The State Park facilities, while limited, contain 13 campsites (without water and electrical hookups), 17 picnic tables, 3 grills, a boat landing and launching ramp, and a shower and wash-house.

During the spring and summer months a myriad of indigenous wildflowers abound including joe-pye weed, iron weed, mist flower, spotted touch-me-not, and many others. Bird watchers also will find the area interesting year around with winter waterfowl such as Canada geese, mallards, black ducks, pintails, teals, and ringnecked ducks frequenting the area.

The old carriage trail still remains at Somerset Place and it's easy to visualize carriages bringing people to the mansion years ago. The huge lawn in front of the house also lends itself to memories drawn from the past. Thus the Somerset Place and Pettigrew State Park represents a blending of the old and the natural.

2. LAND USE INVENTORY

2.1 PAST USAGE. Water based recreation has been the primary use of Lake Phelps in the past. Many hours of enjoyment have resulted from boating around the lake as the scenic beauty of the surrounding land can not be compared to any other area in the state. Sixteen thousand acres of beautifully clear water surrounded by a treeline create a feeling of tranquility and peace.

Aside from boating, fishing has been probably the most enjoyed activity on the lake. Striped bass (rockfish) and other fresh water species thrive in the excellent waters of the lake. Fishermen visit the lake almost daily.

Other water based recreation, such as skiing, swimming and sailing has been enjoyed during the warm spring and summer days. On weekends many families visit the area to participate in the recreational activities and to enjoy the peace, quiet and beauty of the area.

2.2 EXTERNAL INFLUENCES AND ENCROACHMENT. Farming interests adjacent to Lake Phelps have had and are having a direct influence on the quality of the resources and experience available. Clearing operations have denuded the landscape for miles in all directions from the lake shore so that the lake is now subject to a more intense wind than ever before. In addition to carrying smoke from debris burns implemented by the farms, and dust created by massive farm vehicles, the lake has become a colder setting due to the increased chill factor. Old timers in the area say that the lake surface is rougher and more choppy than it was prior to the great land clearing.

A condition of ground water variation is present when farms and other interests pump significant quantities of water from wells to irrigate the fields. While not quantitatively analyzed at this point, engineers, hydrologists and landscape architects are certain that a drawdown of the water table occurs during the dry season when farms are irrigating crops. Besides affecting the growth of plant life, this reduction of water in the soil increases the risks of subterranean peat fires. The lowering of the water table also affects virtually all wildlife habitat and certainly affects the balance of nature as do other farming activities.

Farming operations of this magnitude, if ever implemented adjacent to Lake Phelps, would affect the wildlife habitat, fishery, waterfowl habitat as well as the recreation potential of the lake and park.

Another influence on the ecological integrity of the park and lake is the expanding residential development on the south lake shore. Farming interests are partially responsible as some of their employees are housed in single-family mobile homes and houses on lake shore sites. Some clearing takes place each time a residence is established, thereby reducing the already critically-receding buffer necessary to the lake. A potential for abuse and lake pollution exists at all areas where uncontrolled housing development is occurring.

The influence of various interests are felt intensely in the requests for water release. It is sufficient to note that increased and opposing water release policy requests gave rise to this report.

3. FUTURE TRENDS AND PROJECTIONS

Pettigrew State Park's attendance is growing at an annual percentage rate greater than any other N.C. State Park. There has been no advertising campaign for this park beyond normal State Park media activities and mailings. It is estimated that Lake Phelps and Pettigrew State Park will be visited by 68,830 users in 1980. This estimate is predicted on the assumption that neither expanded advertisement nor development will occur.

The Park is undergoing plans now for expansion of virtually all existing facilities and services. The Division of Parks and Recreation will in the future develop and/or advertise the following facilities and programs:

1) Fishing:

The Lake is known to be one of the finest bass and perch lakes in the eastern half of North Carolina. Once facilities are available, a media campaign will be undertaken to promote sport fishing.

2) Sailing:

The Division is planning a 20 sailboat facility as well as other facilities pertinent to sailboating.

3) Swimming:

If feasible a large swimming beach will be developed at Pettigrew for use by Park visitors.

4) Boating:

A controlled boating program will be instigated in addition to sailing. Limited powerboating, canoeing and rowboating will be provided for. Plans call for new docking and ramp facilities as well as a new concession area.

5) Hiking:

A proposed 10 mile trail will be available to the park visitor. This trail will provide lake vistas, nature exhibits and fishing piers where feasible. This trail is in addition to a proposed nature trail.

6) Nature Study:

An interpretive trail having fine trail shelters with exhibits is now being planned. This trail will be approximately one-half mile long.

7) Camping - Tent and Trailer:

Pettigrew now has thirteen tent trailer camp sites. Plans have been drawn expanding the camping sites to 48. A new washhouse is included with this development. Fishing piers will also be constructed along the camping loop.

8) Family and Group Tent Camping:

If land dependency problems can be eradicated, a forth site, walk-in tent camping facility will be provided.

9) Group Picnic Area:

Two additional areas are planned serving 75 - 100 park visitors each. A small area now serves the entire park.

4. SITE FEATURES AND PROBLEMS

4.1 SEDIMENTATION. The north and northeastern part of Lake Phelps at the boat ramp and surrounding area have sediment accumulations that are several feet deep. The lake area containing the accumulations is quite large, estimated at covering from one forth to one third of the entire lake area. The accumulations are deepest in the area nearest the boat ramp and in the spring of 1976, sediment accumulations were observed to be above the lake water level.

From the north and northeast part of the lake toward the southwestern part of the lake, the sediment accumulation decreased in thickness from several feet to a few inches, respectively. Accumulations also occur on a easterly-westerly transverse, but these amounts are insignificant compared to the accumulation near the boat ramp.

A recent survey of the lake indicates that the sediment occurs in all the lake, but there are extensive areas where the sediment accumulation is discontinuous. In these areas the white sands on the lake bottom can easily be seen through the clear lake water. Small thin patches of sediment have accumulated in small widespread depressions on the lake bottom. Upon inspecting the sediment, obvious small bright blue-greenish particles and loose aggregates can be distinguished from the darker brownish gray colored sediment particles. These blue-greenish finely divided particles have been identified by Dr. Augustus Witherspoon, of the Botany Department at N.C.S.U., as a blue-green algal bloom.

4.2 SEDIMENT CHARACTERISTICS. Sediment in Phelps Lake is thixotropic and has jelly-like properties. When wet, the material is highly viscous and will support the weight of small birds and animals as has been observed and evidenced by tracks. Wind blown dry sediment is very light and will float on the surface of water. Clumps that are baked dry, for example, by the sun or in a laboratory oven, are extremely hard and difficult to break with hand pressure. The sediment appears to dry irreversibly if the water content is removed completely. This characteristic has been noted as a limitation of highly organic and mucky materials if the water table in these soils has been excessive.

The sediment accumulations are unsightly in the clear blue waters of Phelps Lake and its occurrence around the boat ramp is an obvious problem when boats are being launched. Not only do the sediments pose a threat to the life and maintenance of boat motors, but dried sediment mud on boat hulls is difficult to remove.

From the standpoint of the lake's fresh water environment, the sediment pollutes the water for both fish and underwater vegetation. Presently, sediment accumulations cover a significantly large area of the lake bottom and water volume, which could prove to be detrimental to fish and plant life.

4.3 HYDROLOGY. The lake covers an area of approximately 30 square miles and receives precipation at the rate of 53 inches on the average per year. This represents the predominant source of both surface and groundwater replinishment for the area.

There are no known natural surface streams which feed Lake Phelps. There is some overland runoff from the surrounding area in the form of sheet flow, but this amount is insignificant when compared to the total rainfall on the lake itself. When the lake reaches a level of about 12 feet, natural overflow occurs in the form of sheet flow to the Scuppernong River through a low swampy area along the northwest side of the lake. Normal surface drainage away from the lake is by a network of canals located at the northeast end of the lake. The canals have control locks at the lake and also drain farmland between the lake and the river. A new canal was constructed around 1960 along the east side of the lake. This canal has reduced some of the overland inflow into the lake and also, along with the other canals, has effectively short circuited the seepage of ground water to the lake.

Evaporation is the major cause of water loss from the lake. This loss amounts to about .7 of the annual pan evaporation of 51.24 inches measured in the Hoffman Forest or about 36 inches per year.

The current changes taking place in the Lake Phelps area will modify the hydrology of the area somewhat. As more land is cleared and drained by canals for farming the runoff will increase while groundwater discharge will decrease, as will evapotranspiration.

The "ridge" formed by the five-foot contour that crosses Lake Phelps indicates that area to be an area of significant recharge to the Castle Hayne aquifer. Maintaining the water table at the highest level possible is an important aspect of water measurement in the area, not only with regard to Lake Phelps but also to the artesian aquifer system. The piezometric ridge serves as a barrier between brackish water in the Castle Hayne aquifer in the Albemarle Sound area and the large pumping center on the Pamlico River. Unfortunately, very little substantive work has actually been done on the water regime in this area, therefore, long term effects of changes of groundwater levels etc. from drainage and other major development activities are difficult to predict. The degree to which bogs and pocosins serve as water recharge or discharge areas from the aquifers has not been accurately determined.

As indicated previously, we know surface drainage is now controlled by a system of canals that drain into the Scuppernong River from the northeast side of the lake. Also, the drainage pattern has been altered considerably in recent years by a vast network of canals that cross the drainage divide and intercept groundwater that would normally flow toward the lake. The magnitude which the water table and the groundwater divide have been modified by the canal system is not known. Equally perplexing is that the effects of a long period of drought are not known either.

The depth to the water in existing canals indicates the water table has already been lowered excessively in the area entirely surrounding the lake. Proper management of the total groundwater resources in the area will not permit additional lowering, which would also threaten the future of the lake. Present canals, or at least the main canals, should be equipped with gates to maintain, at all times, the highest water table possible to permit cultivation. Under these conditions, the existing canals might provide sufficient water for external uses. Also, the potential for ground fire may be reduced considerably.

4.4 WATER CONTROL GATES AND CANAL MAINTENANCE. Three of the water release gates at Lake Phelps were constructed in the late 1700's and early 1800's by plantation owner Josiah Collins' slave labor. The remaining four gates were built by other landowners between 1920 and 1940.

Prior to 1937 the landowning farmers surrounding the lake opened and closed gates at their convenience using the water for transportation, herring netting, irrigation, drinking and water power. Water from these canals was also used for firefighting. Some gates were left open to reduce aquatic weed proliferation in the lake.

The State of North Carolina acquired responsibility for the gates in 1939 at the same time Lake Phelps was determined to be a "State Lake" and came under control of the Department of Conservation and Development, Division of State Parks (see State Lake's Regulations - Report C.5 in the Appendix).

From 1939 through 1950 all of the gates except one were open just enough to keep down vegetation in the lake. The exception was the Western Canal gate which was open constantly during this time "because people living along the canal banks used the water for drinking and washing clothes".

The gates are essential to the lake principally for maintaining the ecological integrity of the lake, for flood control, management for the optimal recreation resource and wildlife habitat, and finally for release of water by the State.

The Lake Phelps' canals were clogged at the lake end of the canals as a result of opening the gates during tropical storm Agnes in 1971. The silt, which builds up around these gates as a result of the prevailing southwest winds depositing the fine organic silt on the north (canal) side of the lake, was carried into the canals and settled out. Clogging then prevented adequate drainage during rainy periods and flooding of surrounding farm land periodically occurred.

Maintenance excavation of the canals draining Lake Phelps into the Scuppernong River was initiated as a result of a request from the Washington County Board of County Commissioners. Upon receiving this request, DNRCD officially presented the proposal to the Environmental Management Commission (formerly the Board of Water and Air Resources) for approval of State financial participation. The maintenance operation was completed in May 1976.

N.C. General Statute 143-355 requires the N.C. Department of Natural Resources and Community Development to plan, excavate, and administer programs for the preservation, development, and improvement of rivers, harbors, and inland ports, and for dune rebuilding, hurricane protection, and shore-erosion prevention, such programs to include accomplishment of approved civil works projects.

State funding for such projects is in the discretion of the Secretary of the Department of Natural Resources and Community Development. His authority is derived from appropriation bills allocating money for such purposes to DNRCD. Any project eligible for construction under an existing Federal program cannot be constructed under the State program.

The project at Lake Phelps was designed by the U.S. Department of Agriculture, Soil Conservation Service. Plans called for excavation of canals to their original depth and slope which consists primarily of removal of a silt deposit that restricts the flow of water through the canals. Only that vegetation necessary to allow for minimum movement of the excavating equipment was removed from the canal banks and all vegetation within the canals was removed to prevent the accumulation of debris thus damming the canal. All spoils were placed adjacent to the canals on the side with the most open land. It was allowed to dry, and was spread over the farmland. This procedure is expected to improve the quality of the soil since an abundance of nutrients exist in the sediments.

The project was the second project in which the State participated fnancially. In 1955, flooding of the agricultural area drained by the canals initiated action as in this case. However, a more permanent solution to this problem is critically needed in order to optimally utilize the resources available.

Emphasized is the recommendation that repairs begin immediately upon the existing water level control gates. These repairs should include new spindles, wheels and angle iron frames where necessary. At the same time, a thorough report should result from an inspection of the gates and water courses by an engineer(s) to completely ascertain the efficiency, condition, problems of access, costs of repair or replacement beyond that already accomplished by the park staff. A complete maintenance schedule should be established and implemented as a result of the inspection report.

Alternatives to the existing water control gates should be explored and specific recommendations made regarding them.

Maintenance techniques which should be employed prior to the above referenced engineer's report should include a routine greasing of the spindles, applying rust retardant paint to surfaces which are subject to oxidation and rust, rudimentary maintenance of access roads (questions of legal access rights along non-park roads must be permanently settled), and a periodic operational check of all gates.

The canals should be inspected and a long-term maintenance procedure established by the parties involved.

Park staff, given the materials and funds necessary can accomplish the necessary repairs on existing gates without outside assistance.

Preliminary Gate and Canal Maintenance Summary (January 1979)

Moccasin:

The canal appears adequate to carry the amount of water allowed by the 36" discharge pipe.

Western:

Canal problems seem minor, consisting of a growth of weeds and grasses in the water course and along the banks.

Thirty foot:

Flow from the discharge pipe is excellent; only routine maintenance is necessary.

Transportation:

The canal is apparently in good condition but requires some general clearing of debris.

Magnolia:

This canal is inoperable. A complete maintenance excavation is necessary prior to any water release.

Bee Tree:

Upper reaches of Bee Tree are in fair-to-adequate condition. The canal needs cleaning from the Johnson bridge to the gates - a distance of approximately 1 mile.

Water Control Gates

Gate	Condition	Necessary Repairs
Moccasin	Operable	New spindle and wheel
Western	Operable	New wheel, repair spindle uncover and repair discharge pipe
Thirty foot	Operable	Replace spindle
Transportation	Inoperable	Replace and/or repair angle iron frame
Magnolia	Inoperable	New spindle and angle iron
Bee Tree	Operable	New spindle, repair grate and angle iron, uncover and repair pipe as necessary

UPDATED GATE AND CANAL MAINTENANCE SUMMARY (January, 1980)

Moccasin: No Change
Western: No Change
Thirty-foot: No Change
Transportation: No Change
Magnolia: No Change
Bee Tree: No Change

WATER CONTROL GATES

GATE	CONDITION	NECESSARY REPIARS
Moccasin	Operable	Complete
Western	Operable	Repair discharge pipe
Thirty-foot	Operable	Complete
Transportation	Operable	Complete
Magnolia	Operable	Complete
Bee Tree	Operable	Repair discharge pipe

NOTE: The Division of Parks and Recreation is pursuing ways in which to address the condition of silt clogged channels leading from the lake to the canal gate.

Magnolia Canal will not be serviceable until such time as major dredging occurs from the discharge pipe to the canal outflow.

5. HISTORY OF WATER MANAGEMENT AT LAKE PHELPS

As pointed out in the beginning of this report, the absence of any clear, enforceable, written policy encompassing all aspects of water resource management at Lake Phelps demonstrated the critical need for this study.

Lake Phelps is approaching the apex of a pyramid of water management problems evolving from a proliferation of requests from numerous sources to withdrawal of water for a variety of uses. Naturally, these demands bring forth other interest group pleas not to permit water withdrawal or releases from the lake (via the canals, pumping facilities, etc.).

The perplexities surrounding when, how, to who, how much and where, coupled with the question of potential environmental effects and whether water should be released at all has become of international magnitude due to the commercial fisheries interests and water requests made by the superfarms which surround Lake Phelps.

As noted earlier, the lake proper is connected with the Scuppernong River by a network of canals which date from well before 1900. There are control locks on all the canals where they enter the lake. The primary function of the canals is drainage of farmland between the lake and the river, however, the larger canals (e.g., Bee Tree) have been used as navigational corridors in the past.

Based on past records, the opening and closure of the gates has been under control of an informal Watergate Control Committee composed of local farmers. Basically, the farming coalition met, discussed the matter, reached a decision, and informed the Park Superintendent who, in turn, acted on the decision.

Unfortunately, there apparently have been no regular records maintained as to when the gates were opened and closed in the past. The gates were opened during the summer of 1965 to lower the water level for the construction of a boat ramp and closed the following year. Records seem to indicate that they were reopened (and possibly closed and opened one or more times again) prior to November 1969, when, due to low water levels, the gates were closed.

At the December 1969 meeting of the Board of Conservation and Development, a new policy was established. It involved: 1) maintaining a minimum water level in the lake of 11.0 feet (above mean sea level), and opening and closing the gates would rest solely with the Division of State Parks and the local Watergate Control Committee would no longer dictate the operation of the gates (however, they still functioned as an advisory group).

On January 1, 1973, following heavy fall rans, the gates on five of the six canals were opened and remained opened until the summer of that year.

In March 1973 the Board of Conservation and Development met and the 1969 policy was once again slightly modified. The change involved: 1) striving to maintain the lake at levels between a minimum of 10.50 feet and a maximum of 11.20 feet; and 2) opening the gates only if the water level exceeded 11.20 feet and the lake was subject to flooding. The authority for regulating the gates remained unchanged.

This policy has basically remained in effect up to 1977, however, with the increased demands on the lake for water, decisions made under that policy lended themselves to conjectue due to the somewhat arbitrary nature by which they were arrived at. Consequently, this study was undertaken to develop an equitable, objective, comprehensive water management plan, on which policy decisions could be based and substantiated. This resource document will provide the technical base information needed to develop policy guidelines and management decisons with respect to Lake Phelps.

PART B.

TECHNICAL ASSISTANCE FOR LAKE PHELPS LAKE LEVEL MANAGEMENT

Hai Tang 1978

I. INTRODUCTION

High water, low water, and excessive sedimentation problems have been associated with Lake Phelps. The erosion of black soil feeds the lake with nutrients and the prevailing wind deposits the fine inorganic silt on the north shoreline of the lake. When the canals were opened, this inorganic silt was carried into the canals and settled out. This reduced the drainage capacity of the canals. The Soil Conservation Service, in cooperation with the State of North Carolina, had the sediment removed in 1976.

The Pettigrew State Park Master Plan was designed with a lake level at 11.50' above mean sea level. In order to maximize the peak use period (summer) recreational benefits, the lake should be maintained at as high a level as possible, but this would increase the probability of overland flow on the north side which would cause erosion as well as flooding of the nearby houses and farmland. A computer model developed in an earlier study showed that the level can be maintained at a high level (11.50' to 12.00' msl) most of the time if the water were released by opening the gates and overland sheetflow would occur at the same time when the canals are most needed for draining the surrounding farmland. Very likely, the canals would not be able to carry this large release, and as a result, the flooding of the farmland would be unnecessarily prolonged.

This task force reviewed storm data in the lake vicinity and earlier studies and projects of the lake. It was our intention to develop a management plan such that the lake level would be maintained at the highest possible level without prolonging the flooding of farmland when a major storm hits. To do so, we evaluated the frequency of storms, the groundwater-lake relationships, water release rates that would prevent overland sheetflow, carrying capacities of existing canals, and flood flow from the farmland. We also conducted field tests by opening the Bee Tree gate fully, measured the flow rates and observed flow phenomena along the canals, had sediment samples tested in laboratories, and reviewed the trophic analysis.

II. FREQUENCY OF STORMS

Lake Phelps is fed primarily by direct rainfalls. Three rainfall stations (Belhaven, Columbia 2 and Plymouth 5E) are located in the vicinity of Lake Phelps. The records of these stations show that major storms vary from 3 to 7 inches/day with one exception. A galestorm brought a heavy rainfall in the coastal area with 12.5 inches recorded at the Belhaven station on June 30, 1962. Based on the data of these three stations, a distribution of average rainfall intensities for various recurrence intervals is plotted on Figure A.15.

III. GROUNDWATER LAKE RELATIONSHIPS

The extend to which groundwater contributes to the replenishment of Lake Phelps is not precisely understood. The lake is believed to be hydraulically connected to two hydrogeologic units; an unconfined, or water-table aquifer, and an underlying semi-confined aquifer.

The regional flow of water in the unconfined aquifer is from southwest to northeasterly, and flow is intercepted by a perimeter canal which borders the lake on its western and southern side. Precipitation entering the aquifer under the narrow strip of land between the canal and the lake moves toward the canal on one side of its divide and toward the lake on the other. The area in which movement of water is toward the lake is very limited. Figure A.11 illustrates the groundwater movement on the south shore of the lake. The northern side of the lake is topographically and hydraulically down gradient, resulting in the probable loss of lake water by underflow through the unconfined aquifer on that side of the lake.

The peaty and loamy soils in which the unconfined aquifer occurs also serves to provide at least a partial hydraulic confinement to the underlying sand which forms the uppermost semi-confined aquifer. There is evidence that the semi-confined aquifer is exposed in parts of the lake bottom, allowing discharge from the aquifer into the lake when hydraulic heads in the aquifer exceed the level of the lake. Under normal conditions the lake and the groundwater system are essentially in balance so that there is very little flow of groundwater into the lake. Rapid lowering of the lake level would allow groundwater discharge into the lake until the hydraulic heads attain a new state of equilibrium.

Although groundwater movement, especially within the artisian aquifer may provide an inflow to the lake, it is considered to be of a smaller order in comparison with direct rainfalls. Groundwater input would help maintain the lake level to a certain extent during the rainless period, but it would have little contribution in flooding the lake.

IV. CONTROL RELEASE RATES

In order to avoid an overflow from the lake (caused by major storms), it is necessary to calculate the lake elevation under various controlled releases. Figure A.16 compares the accumulated rainfall with the accumulated release for the release rates at 700 and 350 cfs (equivalent to 1 and 1/2 inch/day lake drawdown, respectively). The difference between the recurrence curves and the release curve would be the rise of the lake level for the given storm.

To illustrate the result of Figure A.16, we assumed that the lake level is to be maintained at 11.50" msl as long as possible but not to exceed 12.00' msl. Because the 10 year recurrence does not exceed the 700 cfs release curve over 6 inches, a control release of 700 cfs would prevent the lake level from rising above 12.00' msl no more than once in 10 years (10 percent chance). A control release of 350 cfs, would fail to safeguard the lake from rising above 12.00 msl once in 5 years (20 percent chance).

Besides the drawdown caused by the flow releases, the evaporation also contributes a significant drawdown of 0.25 inches/day (may be expected during the highest evaporation month, generally July or August.)

V. CANAL CAPACITIES

The carrying capacities are calculated at gate, upper reach (where the canal receives little drainage) and lower reach (canal where drainage from the farmland is substantial). The pipe flow at the gate is obtained by using the monographs, published by The Bureau of Public Roads. Figure C.1 (at the end of this report) shows the monograph for concrete pipe under submerged flow condition, and Figure C.2 under inlet control. These gates have front-wall which may govern the flow capacity are verified by broadcrested weir formulas:

$$Q = CLH^{3/2}$$

Where Q is the flow in cfs
C is obtained from Table 5.3 in King's Handbook
L is the length in feet
H is the surcharge head in feet

The carrying capacities of the canals are calculated by the Manning Formulas:

$$V = \frac{1.486}{n} r^{2/3} s^{1/2}$$

$$Q = \frac{K' b^{8/3} s^{1/2}}{n}$$

Where r is the hydraulic (area/wetted-perimeter)
s is the slope
b is the bottom width of the trapezoidal canal
K' is the function of canal shape and is given in King's Handbook of Hydraulics
n is the manning coefficient

With the exception of the n value, the above parameters are strictly governed by canal cross-section and profile. The value of n depends on the surface condition of the canals. A table of n values is also presented in King's Handbook.

In 1974, the Soil Conservation Service calculated the canal adequacy by the same formulae. The SCS chose a very conservative value of n when compared with those given in King's Handbook. A moderate but still conservative value of n = 0.035 is chosen in calculating the canal capacities.

Table 4. shows the carrying capacities at gates, upper reaches and lower reaches of the existing canals. In calculating the pipe capacity under submerged flow condition, the tailwater elevation has a significant effect on the flow rate. Although the elevation may be predicted by iterative trails using the Manning formulas, an error of as much as one foot in tailwater elevation may be expected. A difference of one foot in tailwater elevation may result in a change of flow rate of as much as 30 percent. The figures in that table should be considered as approximate figures. The canal capacities shown in this table should represent the bankful flow as the canals in their 1976 improved condition. Sedimentation and vegetation in the canals since then may obsolete these figures. Therefore, we conducted field tests to verify these numbers.

VI. FIELD TESTS

The aforementioned table shows that Bee Tree Canal has the maximum carrying capacity. Thus we concentrated our data taking on Bee Tree Canal although we tested other canals as well. On September 12, 1978, we installed a stage-recording gage under the bridge on SR 1122. Based on the recorded data from September 12 to October 17, 1978, the water level in the canal fluctuated at small amplitudes, mostly less than 6 inches in a 24-hour period.

On September 15, 1978, we opened the canals and observed the flow phenomena along the canals. We opened the Mocassin Canal gate at 10:15 in the morning and the Bee Tree gate at noon. Due to excessive siltation on the canal entrances, we were not able to open the other canals.

Siltation mainly concentrates on the northeast shore where the existing gates are located. We found little sediment 100 feet off shoreline except on the west side of the boat ramp. The siltation may be attributed to the wind erosion on the surrounding farmland and the south-westerly prevailing wind. On the canal entrances between the lake and the gates, siltation was accumulated to water surface even though the lake level was as high as 11.65' msl. The block of flow by the excessive siltation made the water level drop dramatically at the gate entrance after the gates were opened. We rocked a motor boat through the muddy silt to bring water into Bee Tree Canal. The silt was gradually washed away as the flow increased. Table B.4 shows the depth of the silt in the existing canal entrances, and Figure A.17 shows the laboratory analysis of silt samples taken from Bee Tree Canal.

After the flow through Mocassin Canal stabalized, the water level dropped from 11.65' to 10.60' msl at the gate entrance. Water flowing in the 36" pipe was only 6" depth and was estimated to be 3 to 4 cfs. The water level in the canal varied from 3 to 4 inches. Transported silt was deposited within 300 feet behind the gate. The deposited silt was estimated to be less than 40 cubic yards.

On the Bee Tree Canal the water level also dropped to 10.60' msl at gate entrance. The tailwater level was 9.50' msl. Based on the submerged flow monograph, the flow through the pipes would be 135 cfs. The difference from the Table 4 figure may be attributed to the fact that there is some silt sediment and excessive vegetation on the upper reach between the gate and the 9 foot culvert on SR 1119. The siltation and vegetation backed up the water level higher than predicted.

Although the monograph indicates the flow through the pipes should be 135 cfs, we did not measure the same amount of flow at the 9 foot culvert. We measured 5.1 fps average velocity right behind the culvert and obtained 61 cfs by multiplying the wet cross-section areas within the culvert. This may be due to the fact that the current meter was flushed to about 4 to 5 feet behind the culvert and the velocity is no longer the true velocity in culvert. To confirm our suspicions, we opened the Bee Tree Canal gates again on December 14, 1978. We measured 56 cfs at the 9 foot culvert which is about the same magnitude as we measured previously, but we measured 111 cfs of flow 40' upcanal from the gate. We believed the latter was the actual flow. Obviously, the Bee Tree Canal is governed by the carrying capacity of the upper reach. If the sediment and vegetation are removed, the canal can deliver up to 200 cfs when the lake level reaches 12' msl. Therefore, a flow release of 350 cfs can be met with proper cleanup on the existing canals.

The rise of the water level varied along the canal. Water rose 60 inches right behind the gate and then gradually reduced to 50" 500' downcanal, 46" at 1000', and 28" at 8000'. However, the rise was insignificant on the lower reach. We observed a 3" rise at a stake near Mr. Wilson's farm. We predicted the rise would be 6" if the flow release were 200 cfs. If the upper reach is improved, the rise along the upper reach would reduce significantly.

Silt washed off from the entrance canal also deposited right behind the gate. Three to six inches of silt were detected on the upper reach mostly within the first 1000 feet. Based on the subsequent condition of the canal between the lake and the gate, after flushing it was estimated that 1000 cubic yards of silt were deposited in the first 3000 foot reach.

VIII. FARMLAND RUNOFF

The runoff from farmland varies with soil moisture and vegetation as well as storm magnitude. As much as 50 percent of rainfall may be retained by soil and vegetation. It is believed that the average runoff for a 24-hour storm for various intensities would be between Curve Number 70 to 85 (Figure C.3). The SCS calculated the average runoff from farmland by the following formula.

$$Q = 45\ M^{5/6}$$

Where: M is the drainage area in square miles.

The calculated runoff based on this formula is equivalent to a 3 to 4.5 inch storm depending on preceding soil moisture.

Farmland runoffs are also shown in Table 4. Although it appears that the canals are adequate for carrying the flood flow (750 cfs) from the lake, we should be aware of three facts:

1. Farmland runoff is only equivalent to a 3 to 4.5 inch storm. Any heavier storm would create larger runoffs. The frequency of excession is about once in two years.

2. The canals currently having maximum capacity do not necessarily have enough gate to release the flood water. This is specially true for Moccasin Canal. Moccasin Canal may deliver up to 200 cfs from Lake Phelps, but the pipe-setting can only release 10 cfs.

3. The capacities are calculated at bank-full flow condition. This may result in minor flooding on the lower farmlands.

IX. LAKE LEVEL MODELING

In order to simulate the lake level, we must assume certain management schemes. These schemes by no means prevent us from studying other alternatives. Different management schemes can be incorporated into the computer program without difficulty. The model takes precipitation as input and controls the flow release considering the lake level and the draining needs of the farmland.

Although there are three rainfall gages in the vicinity of the lake, Columbia 2 does not have as long a period of records as Belhaven and Plymouth 5E. The rainfall inputs are generated based on Belhaven and Plymouth 5E stations with 0.84 and 0.16 of weight coefficients, respectively. Evaporation consumption is also adjusted based on Maysville 6 SW data. Groundwater inflow and seepage are assumed in balance, while leakage from the existing gates is estimated to be 10 cfs.

The target lake level is yet to be chosen. The model simulated three likely target elevations of 11.00', 11.25', and 11.50' msl. It assumed that there would be no flow release from the lake until the lake exceeded target elevation, and that water would be released only when the canals are not needed for draining the farmland runoff. In order to determine whether the canals are needed for draining the farmland runoff, we developed a draining need index.

In searching for a mean to indicate whether the farmland is flooding and needs the canals for draining, we modified the SCS antecedent precipitation which adds up the precipitation during the previous five days to indicate the soil moisture condition. Before adding up the antecedent precipitation as a draining need index, we multiplied the preceding precipitation with a 1/t coefficient, where t is the preceding time in days. This gives the nearest storm a higher influence in deciding whether the farmland is flooding. The rationale of this modification is that flooding always recedes as time goes on. A storm five days ago should have less flooding potential than the same magnitude of a storm one day ago. When the draining need index exceeds one inch, we assumed the canals are needed for draining the farmland. Therefore, no flow release from the lake is permitted. When flow release is allowed, the release may be as high as 350 cfs.

The model simulated the daily lake elevation under the above assumptions. Table 5 shows the frequencies of lake level exceeding 12.00' msl and falling below 10.50' msl and their average durations. The exceeding frequencies are in agreement with those that may be interpreted from Figure A.16.

X. LAKE WATER QUALITY - TROPHIC ANALYSIS REVIEW

Several different investigators have studies the nutrient and biological status of Phelps Lake. Disperate values have been reported for both chemical nutrient samples and for algal samples. The lake has been described as mesotrophic in Weiss and Kuenzler's "Trophic State" report. The investigations have shown that between the two most common limiting nutrients (N&P), the lake is generally phosphorous limited, however there has been a suggestion that some other nutrient may be limiting, based on algal assay results. A summary of some of the relevant parameters studies in the various reports is presented in Table 6.1. Also, in Table 6.2, some parameter values abstracted from data in Weiss's report on the Trophic State of N.C. Lakes for tentatively differentiating between trophic levels are presented. Note that cell densities are particularly higher than those suggested as mesotrophic levels and also total P concentrations are high in some of the sampling.

As a P limited lake, it is important to establish a phosphorous budget for the lake. Since Phelps Lake is not supplied by tributary streams and is virtually cut off from groundwater flows due to a surrouding network of canals, the two most important sources of phosphorous to the lake are precipitation (wet and dry) and loading by septic tank drain field leakage in the area along the perimeter of the lake.

Phosphorous input via precipitation is usually a small portion of a P budget, but for lakes with small drainage areas, precipitation and dry fallout can become a major source of nutrients. Data was available from Mark Brinson of ECU for a year of precipitation sampling at the Town of Grimesland, near the mouth of the Tar River, which is approximately 40 miles from Phelps Lake. Extrapolation of this data to Phelps Lake yields a total estimated P input of about 3900-4900 kg/year due to precipitation. P concentrations of wet and dry precipitation are influenced by land use in the area, with more P associated with agricultural land use. The total wasteload of P by residents and visitors to the lake which is discharged to the perimeter of the lake in septic fields is estimated at 133 kg/year, (based on inputs from 40 full time residents, 13 part time residents and 54,000 visitors/year). If it is assumed that about 50 percent of this total reaches the lake, then this loading would be 66 kg/year. Thus, a vast majority of the phosphorous entering Phelps Lake at this time is due to airborne inputs.

The sediment which covers the northeast section of the lake has been tentatively attributed to airborne inputs probably from agricultural activity in the area. This sediment is nutrient rich and seems to support algal growth. Algal assays have shown that algal growth increases in the laboratory when this sediment is mixed with the lake water, but only when temperatures are above 12°C. This work has suggested that the mixing of this sediment with the lake water, as during wind caused mixing, may be responsible for increasing algal growth in the lake. This also suggests that any activity that disturbs this sediment, such as removal by dredging should take place only in the cold winter period.

XII. SUMMARY

We have evaluated the frequency of storms, the groundwater-lake relationships, feasible release rates from the lake, canal carrying capacities and drainage from the farmland, and modeled the lake elevation with the use of a computer. We have also conducted field tests by opening the canal gates and measuring the flow rates and observing the flow phenomena along the canals, and had samples tested in laboratories. Our findings may be summarized as follows.

Major storms in the lake vicinity varies from 3 to 7 inches with one exception. A galestorm was recorded with the heaviest 12.5 inches at Belhave gage on June 30, 1962. Average rainfall intensity for a 2 year recurrence interval is 3.8 inches/day.

Although the lake is believed to be linked with the groundwater system, the groundwater discharge and seepage loss balance each other under normal conditions. Groundwater input may help maintain the lake level when the lake level is low, but it would have little contribution in flooding the lake.

Flow release at 350 and 700 cfs would lower the lake 1/2 and 1 inch/day, respectively. If the lake is targeted at 11.50' msl, a 350 cfs release rate would fail to safeguard the lake from rising above 12.00' msl once in five years, and a 700 cfs release rate once in 10 years. In addition to control release, evaporation loss may contribute an additional drawdown of 0.25 inch/day during the hot summer.

Based upon the improved canal condition of 1976, or the original design condition if not improved, the canals are capable of delivering the 700 cfs of flow release from the lake. However, field tests on Bee Tree Canal, which has the largest carrying capacity, indicated that the canal could only deliver 110 cfs, about half of that calculated, on the upper reach in which siltation and vegetation were also found. It appears that some maintenance on the existing canals would be necessary in order to be able to control the lake level.

Canal entrances between the lake and the gates were clogged with silt so that little water flowed through the gates after they were opened. We rocked a motor boat from the lake to the Bee Tree gate to bring in water to gradually increase the flow rate as silt was washing off. We were not able to do the same maneuver on other canals. The clogged silt should be removed so water can flow through the gates.

Washed off silt deposited right behind the gates, mostly within the first 500 foot reach. Little sediment was added beyond 1000 feet in Bee Tree Canal in which 1000 cubic yards of silt was estimated to have been deposited during the field test.

In Bee Tree Canal, water level dropped one foot flowing from lake to gate after the silt was washed off by the maneuvered increase of flow. Further cleanup of the silt may reduce the drop, but the water level at the gates will not remain at the same elevation as in the lake after the gates are open. For practical purposes the maximum gate flow capacity should be read from the 11.00' msl instead of 12.00' msl for adjusting the drop of water level. Thus a removal of sediment and vegetation from the upper reach of Bee Tree Canal would restore the carrying capacity from 110 cfs to 200 cfs.

Sediment and vegetation are also found in other canals. The excessive amount of silt in Magnolia Canal makes the canal impractical for carrying flow from the lake. Alligator weed in the lower reach in several canals would also reduce the canal carrying capacities.

As the floodwater in the lake would be released only when floods receded, an additional rise of 3 inches in the Scuppernong River should not create any problems under normal conditions. The prolongation of flooding on the farmland is not foreseen. The soil would practically absorb the one inch of weighted draining index.

Modelling results show the frequencies and durations of lake level exceeding 12.00' msl and falling below 10.50' msl. For lake level targeting at 11.00' msl, the lake level would not exceed 12.00' msl based on 1955-1976 rainfall records, but it would fall below 10.50' msl more than every other year. The worst situation would be when the 1957 rainfall repeats. The lake level would fall below 10.50' msl for 155 days from June 23 to November 24 with the lowest elevation falling below 10.00' msl. For a 11.25' msl target elevation, the lake level would only exceed 12.00' msl once in 22 years for a duration of three days, and it would fall below 10.50' msl seven times in 22 years. The duration would still last for 81 days for the 1957 condition. For the 11.50' msl target elevation, the frequencies would be five times in 22 years for exceeding 12.00' msl and twice for below 10.50 msl, but the durations in percentage of time are about equal.

Table C.1
Summary of Available Data on Trophic State Parameters

Parameter	[1]Remote Sensing Report	[2]Trophic Status Report	[3]Draft Mgmt. Plan	[4]Div. of Env. Mgmt.
Conductivity (umhos)	86-103 (92)	69-120 (94)	-	118-140 (125)
pH	4.7-6.7 (5.35)	5.4-6.1 (5.75)	6.4-6.9 (6.6)	5.0-6.0 (5.5)
Chlorophyll a (ug/l)	13.-17.2 (6.4)	1.1-3.3 (2.2)	-	10-40 (16.45)
TKN (mg/l)	.57-1.65 (.94)	.29-.40 (.35)	.81-6.4 (1.75)	.2-1.1 (.37)
NH_3-N (mg/l)	.010.18 (.035)	.10-.195 (.147)	.01-.20 (.076)	.04-.15 (.08)
NO_2 + NO_3-N (mg/l)	.002-.12 (.033)	.096-0.12 (.018)	.13-.28 (.21)	.05-.06 (.05)
TP (mg/l)	.04-.11 (.07)	.022 (.022)	.03-.30 (0.83)	.05 (.05)
Ortho-P (mg/l)	0.0-0.2 (.009)	.007-.013 (.01)	0.0-.02 (.01)	.05 (.05)
Cells/ml	2434-58,581 (13925)	1264-16068 (8666)	38,127	30-76 (44)

[1] Welby, Charles W. and R. E. Holman, 1977. Application of satellite remote sensing to N.C.-Development of a monitoring methodology for trophic states of lakes in N.C. NASA.

[2] Weiss, C. M. and E. J. Kuenzler, 1976. The trophic state of N.C. Lakes. WRRI Report #119. July 1976.

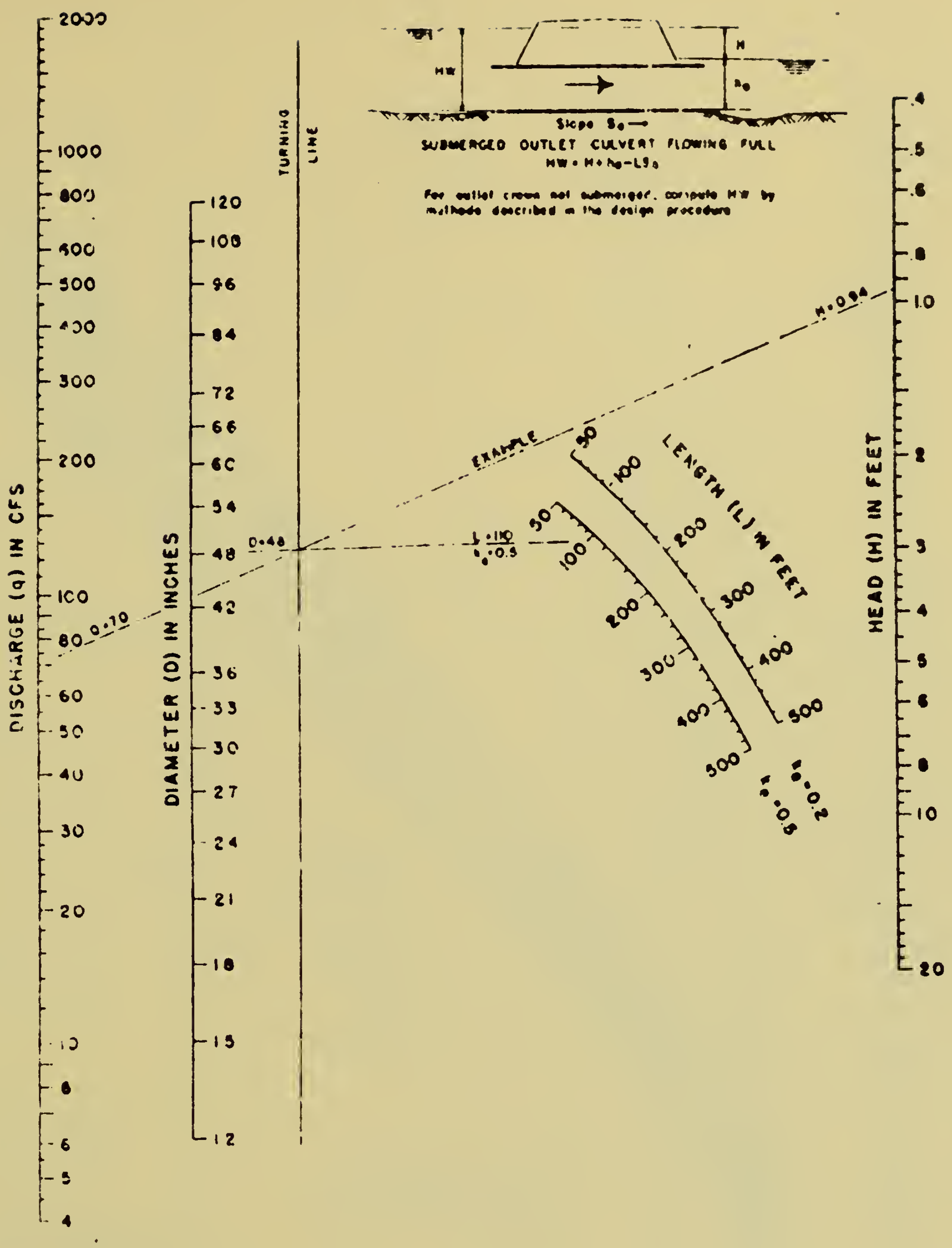
[3] Draft Lake Phelps Management Plan, Dept. of Natural and Economic Resources

[4] Phelps Lake Biological Investigation, DEM, 1977.

Table C.3

Typical Values of Trophic State Indicators as Related to Trophic Status (Weiss, 1976)

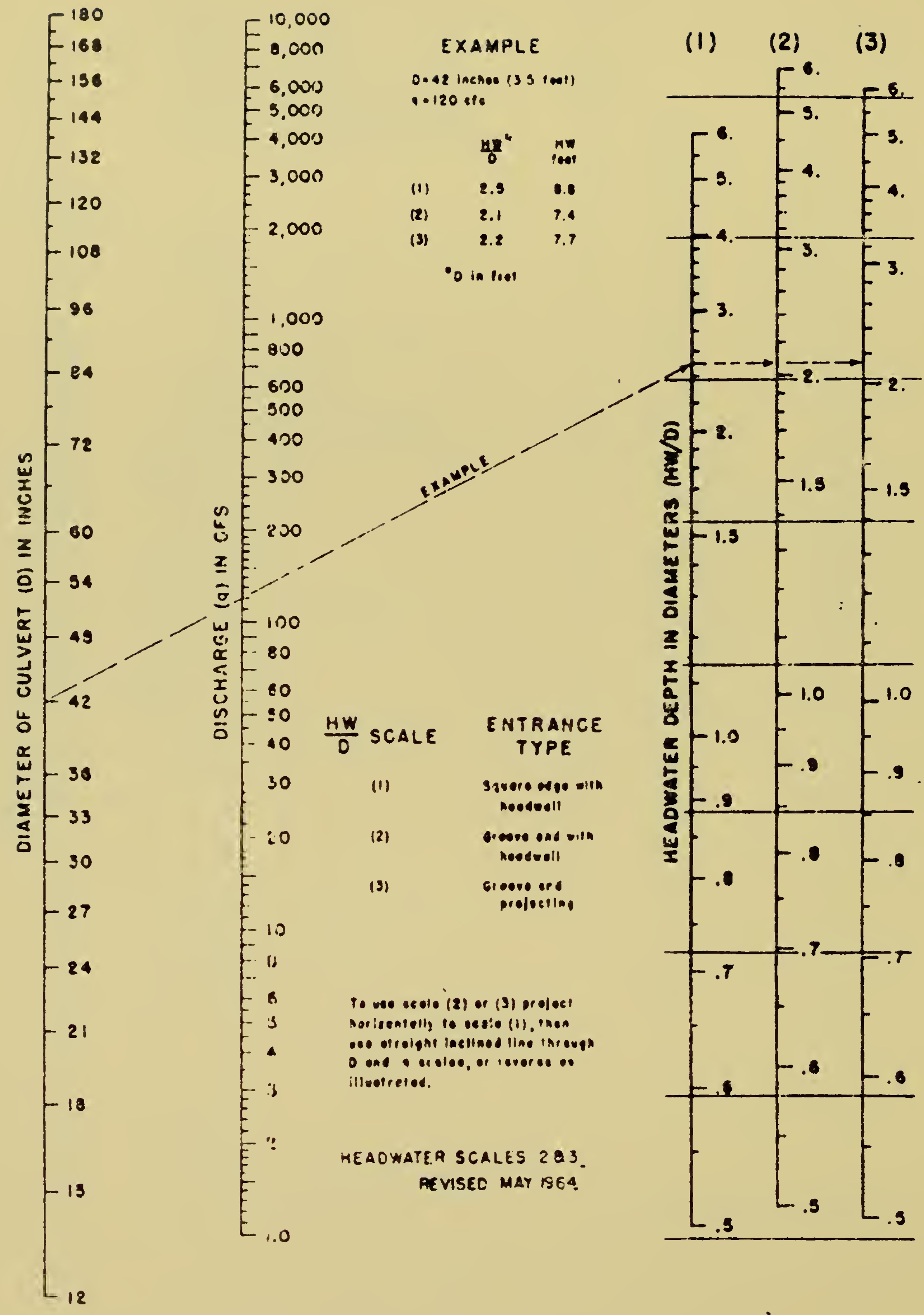
Trophic Level	Tot. Phos. ug/l	Conductivity umhs/hr.	Secchi Depth meters	Chlora *a* ug/l	Environmental Index	Bio-Vol mm^3/m^3	Cell Density No/ml
Hypereutrophic	150	200	0.1	100	500	8000	20,000
B-Eutrophic	80	150	0.5	40	250	4000	10,000
a - Eutrophic	40	100	1.0	15	100	2000	6,000
Mesotrophic	20	50	1.5	6	50	1500	3,000
Oligo-Mesotrophic	10	20	3	2	20	1000	1,500
Oligotrophic				0	0	0	0



BUREAU OF PUBLIC ROADS JAN 1963

Head for concrete pipe culverts flowing full n = 0.012.

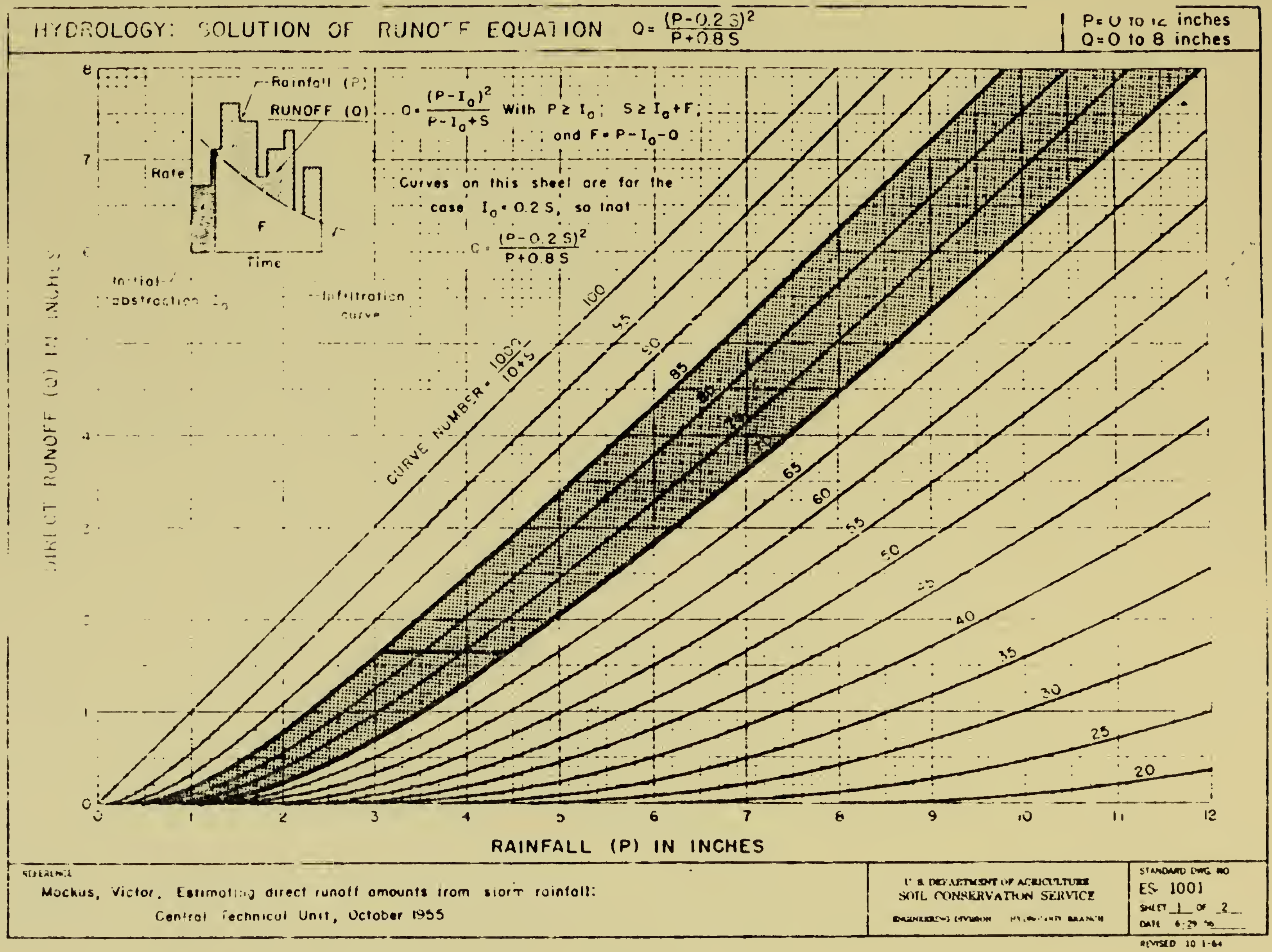
Figure C-1



BUREAU OF PUBLIC ROADS JAN 1963

Headwater depth for concrete pipe culverts with inlet

Figure C-2



Estimated Direct Runoff from Storm Rainfall

Figure C.3

PART C.

A REPORT OF THE RELATIONSHIP OF THE LAKE PHELPS FISHERY TO VARIOUS LAKE LEVELS

James Kornegay 1979

I. INTRODUCTION

Lake Phelps produces high quality angling for several desirable game fish species. Continuance of this fishery resource is dependent upon maintaining water quality and protection of the fishery habitat communities as they now exist. Decisions concerning water level maintenance of the lake may determine the future of the Lake Phelps fishery. It is hoped that the information contained herein will be carefully considered when those decisions are made.

II. DESCRIPTION OF THE FISHERY HABITAT OF LAKE PHELPS

The fishery habitat of Lake Phelps may be partitioned into two distinct communities. The flooded woodland/aquatic macrophyte community exists around nearly all of the lake perimeter. This community is made up of two subcommunities; one being an area of flooded stands of *Taxodium*, *Nyssa*, and *Liquidambar*, and an adjacent band of aquatic macrophytes, primarily *Nuphar*. The woodlands may be flooded for a distance of several hundred feet from the lake's edge and the aquatic macrophyte beds may extend into the lake for fifty to seventy-five yards. The second distinct community is the sand/mud bottom community. This area comprises most of the barren mid-lake bottom and offers very little value as fishery habitat due to lack of cover, structure, or relief.

III. RELATIVE IMPORTANCE OF THE HABITAT COMMUNITIES

Our sampling information indicates that the flooded woodlands/aquatic macrophyte community is the most important habitat community of Lake Phelps. By the use of electrofishing, trawling, gill netting, and scuba diving, we have found that this community supports an abundance of game and forage fish. Game fish which have been taken in samples include largemouth bass, bluegill, pumpkinseed, white perch, black crappie, and chain pickerel. Forage species which inhabit this area are killifish, darters, shiners, and juvenile game fish. The sand/mud bottom areas have been found to be lacking in most game and forage species. Schools of white perch are present in this area during daylight hours; however, gill nets placed along the outer edge of the plant beds were repeatedly seen to have high catches of white perch just after sunset, indicating a diurnal feeding migration to the plant beds and therefore demonstrating a dependency on the aquatic macrophyte subcommunity.

IV. SEASONAL WATER LEVEL REQUIREMENTS FOR FISHERY HABITAT MAINTENANCE

Maintenance of a fishery habitat hinges on the protection of spawning and rearing areas, food sources, and escape cover. From our invesigations, it is apparent that these three entities exist within the flooded woodland/aquatic macrophyte community of Lake Phelps. The actual need for those entities may vary seasonally. During the months of December through February, no known fish spawning occurs, and due to slowing of metabolic rates, predator-prey interactions occur with much less frequency than in warmer months. Therefore, the need for food and cover is reduced. If water levels were to briefly recede from the shoreline during these months, the fishery would probably realize little or no effect. During the months of March through November, spawning and feeding activity within the community is at its highest rate. It is during these periods that inundation of the flooded woodlands/aquatic macrophyte community is absolutely critical.

The N.C. Division of Marine Fisheries proposes to place an anadromous fish ladder on Bee Tree canal which connects Lake Phelps and the Scuppernong River. Their objective is to allow access of anadromous alewife and blueback herring to the lake for spawning. Game fish populations of the lake will benefit from the presence of young-of-the-year herring as a forage species. During the months of March through October, it will be essential that water levels are high enough to permit the fish ladder to function and to permit herring to have access to the shoreline for spawning purposes.

From the information available, it is estimated that in order to properly maintain the fishery habitat of Lake Phelps, a lake level of 11.5 feet above msl must be maintained during the months of March through November.

V. CHARACTERISTICS OF LAKE PHELPS AT VARIOUS WATER LEVELS

The following information represents significant events, relative to the Lake Phelps fishery, which might be encountered at various lake levels:

12.0 feet above msl - All woodlands completely flooded, fishermen report low catches because of inaccessability to fish which are in flooded areas, total habitat area probably at a maximum.

11.5 feet above msl - Woodlands moderately flooded, fishermen report good catches of fish due to accessability, total habitat area at optimum level.

11.0 feet above msl - Woodlands partially desiccated, aquatic macrophyte beds still flooded, fishermen report good catches, habitat area less than optimum, boat launching difficult.

10.5 feet above msl - Most woodlands completely desiccated, some of the aquatic macrophyte beds becoming desiccated, significant habitat areas disappearing, boat launching nearly impossible.

10.0 feet above msl - Woodlands and aquatic macrophyte beds desiccated, lake shoreline exposed to air, significant fishery habitat absent, boat launching impossible.

PART D.

LAKE LEVEL FLUCTUATION IMPACT UPON THE VEGETATION OF THE LAKE PHELPS NATURAL AREA

John Taggart 1979

The Lake Phelps Natural Area is approximately 40 acres in size and is located within Pettigrew State Park along the north shore of Lake Phelps in Washington County, North Carolina (see map). The natural area is bounded by S.R. 1166 to the north, the lake to the south, Thirty-foot Canal to the east, and Western Canal to the west. This band of swamp and lowland forest is approximately 350 feet in width and 3 miles in length. The rather narrow natural area is a remnant of extensive wetlands which surrounded Lake Phelps and have largely been cleared for agriculture and private residences.

Studies done by Wilson (1974) and Radford (1973) conclude that the natural area is dominated by baldcypress (*Taxodium distichum*) and a herb layer. Canopy species also present include sweet-gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), swamp black gum (*Nyssa sylvatica* var. *biflora*), and tulip poplar (*Liriodendron tulipifera*). The subcanopy and shrub species do not comprise a dominat (50% or greater) cover and are represented by scattered paw pay (*Asimina triloba*), holly (*Ilex opaca*), red bay (*Persea borbonia*), sweet pepperbush (*Clethra alnifolia*), Virginia tea (*Itea virginica*), and spicebush (*Lindera benzoin*). A number of vine species occur throughout the community and make access to the forest somewhat difficult in certain areas. Typical vines include rattan vine (*Berchemia scandens*), pepper vine (*Ampelopsis arborea*), cat briers (*Smilax* spp.), honeysuckles (*Lonicera* spp.), and poison ivy (*Rhus radicans*). The herbaceous layer is well developed on hummocks and high ground with typical species being jack-in-the-pulpit (*Arisaema triphyllum*), marsh pennywort (*Hydrocotyle umbellata*), lizard's tail (*Saururus cernuus*), jewelweed (*Impatiens capensis*), false nettle (*Boehmeria cylindrica*), and several ferns. Spanish moss (*Tillandsia usneoides*) grows epiphytically on the branches of canopy and subcanopy species.

The shoreline of the natural area is gradually being built up by water deposited sediments pushed to the north shore by the prevailing southwesterly winds (Div. of Parks and Recreation, 1977). Continued accretion over many decades may result in an organic levee similar to one (observed by the author) on the east shore of Great Lake in the Croatan National Forest. This levee is presently covered with a sweet-gum dominated forest and only a few scattered cypress along the shoreline. Whether this forest is the product of natural succession or human disturbance is uncertain (Taggart, 1978).

Human control of the lake water level is accomplished by a series of flood gates which can be opened to drain lake water into adjoining canals. Lake Phelps is situated approximately 3-5 feet higher than the surrounding terrain and even during periods of relatively low lake levels, water could be released through the gates.

In considering the effect of water level fluctuations on plant community composition, it is helpful to examine past evidence of such changes. Wilson (1974) noted that there must have been a previous high water level(s) because of the cypress knees observed some distance from the shore. Conversely, for cypress to germinate along the shore, a past low water level must have occurred since the seedlings cannot tolerate flooding for sometime following germination (USDA, 1974). Wilson (1974) also noted that the distinct distribution of cypress size classes may indicate extreme rather than gradual water level changes.

Unfortunately, there have been no studies made to determine how much shoreline would be exposed or flooded as a function of human lake level manipulation (e.g. how many feet of shoreline would be exposed if the lake level were lowered one foot). This fact combined with the variables of rainfall, evaporation, wind drive waves, seasonal drought, etc. makes a quantitative estimate of the impact on the natural area virtually impossible. The only conclusions which can be drawn are potential changes in general successional trends based on scientific knowledge applied to the community found in the natural area.

Assuming the lake level is lowered, a number of changes in species composition will take place over time. Areas in the draw down zone will be gradually invaded by the seedlings of red maple and sweet-gum. These species will successfully establish in areas with moist exposed soil and the mature trees will survive if flooded less than 41% of the growing season (Tesky and Hinckley, 1977). Tulip popular is more sensitive to flooding and could only survive as mature trees in areas flooded less than 17% of the growing season. Swamp black gum is a species able to tolerate wetter regimes than sweet-gum or red maple, but it cannot compete with wetland hardwood seedlings where sun light is limited (Ms. Julie Moore, personal communication). Willows (*Salix* spp.) may also be expected to invade moist open areas. Although the cypress seedlings will be outcompeted in the draw down zone, they will be able to invade areas near the new shoreline formerly too wet for germination. Seedling development of *Taxodium distichum* is detailed by the USDA's Silvics Handbook (1974):

> "under swamp conditions, the best seed germination generally takes place on a sphagnum moss or a wet-muck seedbed. The main requirement for germination is abundant supply of moisture for a period of 1 to 3 months after seedfall. Seeds covered by water for as long as 30 months may germinate when the water recedes. On better drained soils, seeds usually fail to germinate successfully because of lack of surface water. The exacting requirements for moisture in early life seem to furnish the key to the whole question of baldcypress distribution.
>
> For baldcypress to become established in swamps, the seed must sprout after the water recedes, and the seedling must grow tall enough the first year to stay above the floods except for short periods. Seedlings often reach heights of 8 to 10 inches during the first season and 16 to 20 inches during the second season. Growth is checked when the seedling is completely submerged by flooding, but submerged seedlings have produced new shoots when the tips were exposed in the air. Prolonged submergence, however, may cause seedling mortality."

Subcanopy, shrub, and herb layer species will also increase in the newly invaded hardwood areas. Continued deposition of sediments on the shoreline will create a rim upon which cypress will establish.

If the lake level were permanently raised, the canopy would open following the death of hardwood species. Cypress and swamp black gum seedlings would invade areas opened by the new inundation regime. The cypress forest near the shore will persist, but with the increased water level, seedlings would be prohibited from germinating and maintaining the stand. The result will be a non-reproducing stand of cypress which will be gradually replaced by aquatic species or highly water tolerant shrubs and trees such as button bush (*Cephalanthus occidentalis*) and willows.

It is apparent that the degree to which flooding will be reduced or increased is going to dictate the future vegetational composition of the natural area. The very narrow shoreline configuration of the community makes the swamp forest particularly vulnerable to changes of this nature. An increase in water level will decrease the width of the natural area and expand cypress dominance inland. If the water level were lowered, the natural area will increase in width and hardwoods and associated vegetation will invade the draw down zone while cypress will invade the open newly exposed substrate along the shoreline.

PART E.

A PRELIMINARY REPORT ON ALGAL ACTIVITY IN PHELPS LAKE, NORTH CAROLINA

A. M. Witherspoon 1976

I. PREFACE

It has been suggested that strategies involving environmental studies have developed along three lines, that of (1) sacrificing generality to gain realism and precision, (2) sacrificing realism to gain generality and precision, (3) sacrificing precision to gain realism and generality. These strategies have developed in an attempt to reduce complex ecological systems into tractable models which assist in understanding, predicting, and managing natural systems.

This report does not propose to utilize either of the three strategies heretofore stated. However, an effort was made to utilize the conceptual mechanism of number three above. Certainly it can be understood that a "one time sampling effort" can not generate any degree of precision. Nevertheless, we have utilized initial "ground truth" to provide some realistic generalities.

Thus, this report considered three generalities that are of ecological significance to the future of Phelps Lake:

1. The presence in the lake of algal species that are capable of producing a wide-spread algal bloom.
2. The interrelationship between the sediment sludge deposits found in the lake and the presence and/or location of the algal species of particular concern.
3. The removal of the sediment sludge deposits with possible consequence on increased algal growth in the lake.

The findings reported here should not be considered as conclusive to any degree of finality. Nevertheless, they may be weighted in light of the experimental designed relative to their creation, i.e., one day sampling in time and space with subsequent laboratory analysis.

II. INTRODUCTION

Great concern has been expressed regarding the present and future quality of our freshwater lakes, rivers, estuaries, and water bodies in general. This concern is not without cause. It is clearly evident from historical data that our natural aquatic habitats have been under the threat of man imposed pollution in one form or another for a number of years. Lack of attention to these bodies of water often leads to eutrophication, a condition which leads primarily to a rapid acceleration of the destruction of the water resource.

The process of eutrophication is caused specifically by the supply of plant nutrients to the aquatic environment even though other factors are involved, such as morphometric relations and the degree of biological utilization of the nutrient substances. The manifestation of eutrophication is the increasing of primary productivity, in extreme cases, the water bloom phenomenon develops and in stagnant water oxygen supply becomes depleted. This leads to fish kills and all the other ramifications that render a recreational area useless.

It is encouraging that the administrators of our recreational lakes in North Carolina are seeking information before the fact, and not merely to treat, after the fact the water quality in the state's natural lakes. One such lake that may have a developing problem is the Phelps Lake in Northeastern North Carolina.

This report is the result of a one day sampling run over pre-determined and randomly selected sections of the lake. The sampling and subsequent laboratory investigation included the following:

1. surface to bottom temperature determinations
2. pH determination (field and laboratory)
3. phytoplankton determinations
4. algal assay for limiting nutrients
5. biological investigation of sediment sludge samples
6. investigation of algal growth in basic nutrient medium and lake water medium in relation to the sediment under varying temperatures and light intensities.

III. MATERIALS AND METHODS

Fourteen sampling sites were located on the borders and central section of Phelps Lake. The first site was located near the boating dock and close to a sediment bed that aggregated to the west side of the dock extending from the shoreline about 40 feet into the lake bed. From this station a motorboat was driven for five minutes at 15 MPH to establish a series of nine other stations. Station one through nine covered a distance from the dock to the far side of the lake. Stations ten through eleven were formed on the left side of a perpendicular to the line of stations, and stations twelve through fourteen formed the right side of the perpendicular. Each station was approximately one fourth to a mile apart. A short description of each station can be seen in Table C.3.

At each station the following measurements or samples were taken:

1. Temperature, surface and bottom waters
2. Dissolved oxygen surface and bottom water
3. A water sample six inches to one foot deep and along the bottom
4. Hydrogen ion concentration (pH)
5. Mats of algal samples wherever possible
6. A special sample of sediment was taken at station one.

All samples were returned fresh, in ice, to the North Carolina State University Phycology Laboratory, 1234 Gardner Hall, for further analysis.

In the laboratory an algal assay was imposed on the lake water according to the standard methods of the Provisional Algal Assay Procedure (1). Cell counts were made either by the Unithol Settling Chamber technique or with a Beckman Spectrophoto metric device at 750 nm. Incubations were carried out in an environmental control growth chamber, or in an envioronmental control growth room. Algal Growth potential from the sediment was determined by mixing and bathing the sediment with lake water or with Bolds Basal Medium (BBM).

IV. RESULTS AND DISCUSSION

Chemical and Physical Factors:

Temperatures throughout the day did not vary more than one degree centrigrade (22.5-23.5) between stations one and fourteen. Likewise, pH remained fairly constant, varying between 6.4 and 6.9. It appeared that neither pH or temperature was having a particular effect on the lake in so far as potential for algal growth was concerned. As can be seen in Table C.4, dissolved oxygen profiles showed little change with depth or from station to station. The small degree of change shown was accounted for when the evolution of oxygen by bottom growth algae was considered.

Table C.3 Sampling Sites - Phelps Lake

Site	Dormant Species	Description of Stations
P-1	*Coccochloris stagnina*	Bottom covered with sludge sediment
P-2	*Coccochloris stagnina*	Mixed sludge--Sand bottom
P-3	" "	" "
P-4	" "	" "
P-5	" "	" "
P-6	" "	" "
P-7	" "	" "
P-8	None	Sandy bottom no sediment
P-9	*Coccochloris stagnina*	Solid sludge-like bottom
W-10	"	Sludge bottom covered with algal
W-11	"	Sand bottom--no algae--water clear-Lily pads growing
W-12	*Coccochloris stagnina*	Close to pier near 1st Colony homesite. Algal growth and sediment sludge.
NE-13	"	Sand bottom with patches of sludge containing growth
NE-14	"	Bottom covered with sediment

Table C.4 Temperature, pH, and Desolved Oxygen at two depths in stations 1-10, Phelps Lake, N.C.

Station & Depth	Temperature	pH	Desolved O_2
1. Top	23.5	6.4	10.5
Bottom	22.0	6.9	10.8
2. Top	22.0	6.4	10.2
Bottom	22.0	6.9	10.7
3. Top	22.0	6.8	10.6
Bottom	22.0	6.8	10.6
4. Top	22.0	6.8	10.6
Bottom	22.0	6.8	10.5
5. Top	22.0	6.4	10.7
Bottom	22.0	6.4	10.6
6. Top	22.5	6.4	10.6
Bottom	22.0	6.4	10.6
7. Top	22.5	6.4	10.5
Bottom	22.0	6.4	10.5
8. Top	22.5	6.4	9.6
Bottom	22.0	6.8	9.6
9. Top	23.0	6.6	10.0
Bottom	22.5	6.8	9.8
10. Top	23.5	6.6	9.8
Bottom	22.5	6.6	9.9

Table C.5. Nutrient Concentration--Mg/l Phelps Lake

Site	TKN	NO_3-N	NO_2-N	NH_4-N	T-P	Otho-P	Chloride
Top 1	0.90	0.25	0.0	0.04	0.06	0.0	9.9
Bottom 1	1.03	0.25	0.0	0.04	0.07	0.0	10.6
2	0.83	0.22	0.0	0.02	0.06	0.01	8.6
2	5.64	0.22	0.0	0.02	0.06	0.01	8.9
3	0.83	0.22	0.0	0.02	0.06	0.01	8.9
3	5.60	0.22	0.0	0.02	0.06	0.01	8.9
4	0.83	0.21	0.0	0.01	0.06	0.01	8.9
4	5.40	0.22	0.0	0.03	0.06	0.00	8.8
5	0.81	0.22	0.0	0.02	0.06	0.01	8.6
5	5.0	0.20	0.0	0.02	0.04	0.00	8.9
* 10	1.47	0.15	0.0	0.20	0.03	0.01	10.0
10	1.50	0.13	0.0	1.15	0.05	0.004	9.0
11	2.39	0.16	0.0	0.14	0.05	.005	9.9
11	2.33	0.16	0.0	0.15	0.05	0.01	10.0
12	1.31	0.26	0.0	0.08	0.08	0.02	12.4
12	8.04	0.20	0.0	0.06	0.49	0.02	8.8
13	1.77	0.16	0.0	0.16	0.3	0.01	9.8
13	4.37	0.15	0.0	0.20	0.28	.004	9.6
14	6.41	0.28	0.0	0.07	0.07	0.02	10.9
14	1.11	0.24		0.03	0.07	0.01	9.5

* No samples for sites 6-9.

Secchi Disk readings above the one percent (1%) light level were observed at all stations except those where bottom coverage was thick with sludge-type sediment that dominated the station close to the dock. The surface water was drinking water clear and void of any visible algal growth. Two exceptions were seen at stations one and twelve. At these two stations organic matter and algal growth was very evident, even with the human eye.

Biogenic Compounds:

Greatest attention on routine chemical analysis of water from aquatic systems has been centered on nitrogen and phosphorus compounds. These two compounds are presumably the most critical for primary production. Phelps Lake was extremely low in these two compounds on the day of sampling. Othophosphate was sometimes undetectable, and never exceeded more than .02 ug/l (Table C.5). Nitrate-nitrogen like amonia-nitrogen was very low. Figure C.4 suggest that there are small differences at some stations between the top and bottom samples. It is interesting that where bottom samples of either compound was less than top samples, the species Coccochloris stagnina was growing rather well. This would indicate a high uptake of the available nutrients where the algae was highest in biomass. The very low concentrations of biogenic compounds could explain why the lake was low in both the number of different species and in total biomass.

If the concentration of biogenic compounds found in the lake on the day of sampling is indicative of seasonal levels, it is safe to say that there is no immediate threat of prolific algal growth in the lake proper. Further evidence in support of this statement can be seen in Figure C.4. These data indicated that even when small amounts (.075 mg/l) of nitrogen and phosphorus were added to lake water there was only a slight increase in growth. With higher concentrations of nitrogen and phosphorus, growth increased only about fifty percent over growth in lake water medium. However, care must be taken when considering these data. The experimental design was only a partial factorial utilizing only nitrogen and phosphorus. It could well be that some other nutrient is limiting in the lake and would thus, prevent an accurate assessment of growth. A full factorial experiment in time and space would be necessary for a more reliable analysis. Nevertheless, as far as the nitrogen and phosphorus growth promotion is concerned, neither was in concentrations great enough to cause excessive algal growth.

Algal Biomass:

Determination of algal biomass proved most difficult because of the presence of a dark sludge-like sediment intermixed in all samples where algae was found. However, a close approximation of the total cell numbers found on the day of sampling is listed on Table C.6. Coccochloris stignina and one species of Anacystis, were found in all samples that contain algae. In the area of station one, Coccochloris was thick enough to be seen along the bottom sediment with the human eye. While this species was found in every sample, only sparse amounts were located outside the fifty yard boundary of station one. The very low nitrogen levels and the total lack of detectable levels of ortho-P at this station presents a very puzzling picture. Previous analysis of the sediment indicated the presence of nitrogen and PO_4 in an amount higher than that found in the surface waters. Either the algal growth had reached it's maximum potential standing crop, utilizing the nutrients that were previously available, or there was ample exchange of nutrients with the sediment to sustain growth at some level. There is evidence to suggest that some blue-green algae can utilize organic phosphorus. Organic phosphorus was not determined in these samples. However, as can be seen in Table C.5, total phosphorus is slightly higher than ortho-p which suggests the presence of phosphorus in some other form.

It was of interest that all species found were associated with the sludge-like sediment. Further, at the stations where the sediment was in greater concentration, the higher algal species and biomass was found. It seemed important enough to attempt a better understanding of the nature of the sediment with respect to algal growth.

There is no evidence to suggest the number of years, or the season of the year that Coccochloris has appeared in such high biomass at the dock. It is known, however, that the sediment has been a part of the dock area for some time. If the algae is a late arriver to the area, then it is reasonable to assume that there exists some specific affinety for or relationship with the sediment. We at least know that the blue-green algae thus far found in the lake---was only found in close proximity with the sludge-like sediment.

Source of Nutrients:

A report by the U.S. Geological Service prepared in cooperation with the North Carolina Department of Natural and Economic Resources on the impact of agriculture developments in the Phelps Lake region delineated the source of water to Phelps Lake. It appears that water enters the lake primarily from rainfall, however, some ground water from the west side empties into the lake. In a study by Lee et al, (1966) and Brezonik and Lee (1969) from 2 to 12% of the phosphorus found in lakes was estimated to have been contributed from precipitation on the lake surface. If these are only partially correct with respect to Phelps Lake, such concentrations would make a significant contribution to the nutrient budget.

The average precipitation record over the last 56 years in this area was 52.37 inches. The lowest precipitation was 31.37 inches. It is fairly certain that precipitation has been adequate in most years to support the lake. Yet there are no past records of an increase of nutrients in the lake or in the sediment. There is no evidence of eutrophication or even moderate algal growth ever occurring in the lake. As late as 1966, Gambell and Fisher reported the concentration of nitrate-N in Phelps area precipitation to be .08 mg/l. During the same period these workers measured the nitrate-N concentration to be 0.10 mg/l in the lake. According to our records, Table C.5, the nitrate-N concentration has increased slightly. The Cambell report made no reference to phosphorus, either in the lake or in rainwater. Our records show that total phosphorus levels ranged from 0.03 to 0.49 mg/l, while ortho-p concentrations ranged from 0.0 to 0.02mg/l.

While these concentrations of phosphorus and nitrogen are high enough to support algal growth but not to the extent found on the sampling date; at least not for a sustain period. The question is, why the algal growth and why the close affinity with the sludge-like sediment. An attempt was made to better understand the sediment-algal growth dynamics.

Sediment Activity:

The sediment in the lake has a greater concentration of nitrogen and phosphorus than the overlying water and is a potential nutrient source (for a detail description of sediment nutrient concentrations see the report by M. Ray Tucker, 5 February 76). Even though these reported concentrations were not extreme, they were, however, adequate to support some biological activity. The complexities involved in sediment release of nutrients will not be considered here. However, an experiment was undertaken to determine if nutrients were released to the lake waters from the sediment.

Autoclaved Sediment Samples:

1. 50% of the sediment returned to the lab was autoclaved for 30 minutes at 15 psi. Sub-samples, in 300 ml beakers were set-up, each with equal quantities of sediment.
2. Equal aliquots of milipore filtered lake-water was added to one half of the sub-samples. The sediment was mixed with the lake water and allowed to stand for 24 hours; making a sediment-lake-water media. Bolds Basal Medium, a standard algal growth medium was added to the second half of the autoclaved sediment samples; making a sediment-nutrient media. The BBM samples were mixed and allowed to stand for 24 hours.
3. After 24 hours the samples of each media type were subdivided into "Stagnant" and "Mixed" groups, and incubated in temperatures of 6, 12, 15, 20, and 25 oC for 5-10 days at 300 ft.c. of light. An equal alliquot of cells (Coccochloris stagnina), previously isolated from the lake water were inoculated into each culture. The mixed cultures were disturbed every three hours during the day, while the Stagnant cultures were not disturbed throughout the incubation period. After five days increase in cell number was determined.

Non-Autoclaved Sediment Samples:

1. The other half of the sediment was not autoclaved. The samples were incubated as was the autoclaved sediment but with two exceptions:
   a. no cell inoculum was added to the sub-samples
   b. no incubation at 25°C (we ran out of sediment)

A control of autoclaved lake water was incubated at each temperature to test the normal growth of the species.

A series of experiments were incubated under different light intensities, but the results of these experiments are incomplete. To-date, however, 250-300 foot candles of light seem optimum for this species. In fact no appreciable difference has been seen between 200 and 350 ft. c. of light.

As is shown in Table C.7 and C.8 "stagnant" or "mixed" sediment had little or no effect on the growth of the algae between 6 and 12 degrees centigrade. In fact, in the lake-water-sediment (LWS) stagnant samples, there was no appreciable change in growth at any temperature. This was quite opposite to the lake-water mixed (LWM) samples. In these samples growth increase was initiated at 12°C and continued through 25°C. This suggest that nutrients were released from the sediment under turbulent conditions. While it is true that the increase in growth could have been a factor of nutrients in the lake water and not from the sediment, the lake-water control would tend to invalidate that thesis. There was hardly any growth increase in the lake-water control. It is obviously premature to extrapolate these results to the _in situ_ role of sediments in the lake. But it would seem that mixing is the most effective mechanism to release sediment nutrients into the water if that were desired. Alternately it is apparent that the single most effective means of limiting release is prevention of mixing. However, during high winds sufficient currents may be generated in a shallow lake like Phelps to stir sediments with the water and release considerable amounts of nutrients.

Table C.8 shows the results of algal growth without autoclaving the sediment or without the inoculation of the cultures with test algae. Again there was no appreciable growth until the temperature increased above 12°C. This was true when the culture remained stagnant even though the nutrients were adequate to support a large algal biomass; as was seen in the BBM controls.

It appears that two factors were interacting to cause algal growth in association with the sludge-like sediment: 1) The physical mixing of the sediment that released the nutrients into the water column, and 2) A change in temperature above a critical norm. Preliminary results suggest that nutrients are very limiting in the lake but that some nutrients reside in the sediment. If these nutrients are released by disturbing the sediment(mixing) and the temperature of the water is greater than 12°C then algal growth may occur.

If further field experimentation proves our results to be valid, it would then appear that removal of the sediment from the lake dock area could be accomplished during the winter months. However, no work has been done to determine recovery time after disturbance of the sediment. Naturally the size of the area and the degree of the mixing would be factors in this regard. Further study is needed to make that determination.

Agricultural farming techniques that create dust clouds from the fertilized fields that settle in the lake or are washed down with rainfall, and the run-off from septic tanks on the west side of the lake could very well be a big source of the small, but significant nutrient increase in the lake. Phosphorus could settle to the sediment and move with it as wind and water waves force the sediment to the opposite side of the lake. This could account for the sediment-algal dynamics as was observed in the lake.

Table C.6 Total species found in water samples from Phelps Lake.

Species	Cells/ml
* *Anacystis incerta*	$860\text{-}8.6\text{X}10^{2}$
Anacystis montana	$360\text{-}3.6\text{X}10^{2}$
Coccochloris stignina	$34860\text{-}3.5\text{X}10^{4}$
Lyngbya subtilis	$1984\text{-}1.98\text{X}10^{3}$
Nivicula sp.	$24\text{-}2.4\text{X}10^{1}$
Oscillatoris sp.	$39\text{-}3.9\text{X}10^{1}$

*Also called *Microcystis*

Sediment Samples

Diatom frustules
Algal spores
Pollen grains

Table C.7 Growth of Coccochloris stagnina in Autoclaved sludge formed media with and without nutrient addition (Cultures were incubated for five days at 300 ft.c. of light). All controls were grown in normal Bolds Basal Medium (initial inoculum = 1 X 10^3 cell/ml)

Stagient Growth in a sludge bottom media				Mixed Growth in a periodic mixed bottom media			
	Growth in cells/ml				Growth in cells/ml		
Temp. oC	S + H_2O	S + BBM	Control Media	Temp oC	S + H_2O	S + BBM	Control Lake Water
6	1.0 X 10^3		1.3X10^3	6	1.1X10^3		1.3X10^3
6		1.2 X 10^3		6		1.25X10^3	
12	1.0 X 10^3		1.9X10^3	12	1.4X10^3		1.2X10^3
12		1.7 X 10^3		12		1.8X10^3	
15	1.4 X 10^3		2.4X10^3	15	1.8X10^3		1.3X10^3
15		2.6 X 10^3		15		2.5X10^3	
20	1.46X10^3		8.2X10^4	20	2.6X10^3		1.38X10^3
20		8.0 X 10^4		20		8.3X10^4	
25	1.4 X 10^3		8.8X10^4	25	2.94X10^3		1.3X10^3
25		8.9 X 10^4		25		9.2X10^4	

Autoclaved filtered

S + H_2O = Sludge + Lake Water

S + BBM = Sludge + Bolds Basal Medium

Table C.8 Growth of Coccochloris Stagnina in non-autoclaved sludge formed media with and without nutrient additions. (Cultures were incubated for ten (10) days at 300 ft. c. light).

Growth in a non-disturbed sludge bottom			Growth in a disturbed sludge box		
	Growth in cells per ml			Growth in cells per ml	
Temp. o_C	S + H_2O Top o_C	S + BBM Bottom o_C	Temp o_C	S + H_2O Top o_C	S + BBM Bottom
6	$1.4X10^2$		6	$1.2X10^2$	
6		$1.8X10^2$	6		$1.9X10^2$
12	$1.46X10^2$	**	12	$1.4X10^2$	
12		$1.9X10^2$	12	**	$1.96X10^2$
15	$1.4X10^2$		15	$1.97X10^2$	
15		$2.4X10^3$	15		$2.6X10^3$
20	$1.48X10^2$	*	20	$2.8X10^3$	
20		$2.9X10^3$	20	*	$3.1X10^3$

PART F.

NORTH CAROLINA STATE LAKES REGULATIONS

State of North Carolina
Department of Natural Resources
and Community Development

SUBCHAPTER 12C - STATE LAKES REGULATIONS

SECTION .0100 - GENERAL PROVISIONS

.0101 AUTHORITY AND PURPOSE

These rules are promulgated pursuant to the authority given in North Carolina General Statutes, Chapter 113, Section 35. White Lake, Singletary Lake, Bay Tree Lake, Jones Lake, Salters Lake, Lake Waccamaw, and Lake Phelps are the property of the State of North Carolina and administered by the North Carolina Department of Natural Resources and Community Development, division of parks and recreation. All use of state lakes shall be controlled and regulated by the regulations in this Subchapter which are hereby legally posted. The cooperation of the public in observing and enforcing these regulations is earnestly requested.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976;
Amended Eff. April 4, 1979.

.0102 DEFINITIONS

Definitions as used in these rules:

(1) Department. Means the Department of Natural Resources and Community Development;
(2) Division. Means the division of parks and recreation;
(3) State Lake. The term state lake or state lakes, unless specifically limited shall be deemed to include all property up to the mean high water mark, whether covered by water or not, in White Lake, Singletary Lake, Bay Tree Lake, Jones Lake, Salters Lake, Lake Waccamaw, and Lake Phelps;
(4) Mean High Water Mark. The highest point on the shore of any lake to which water reaches under normal circumstances;
(5) Regulations. Any regulation duly adopted by the Department of Natural Resources and Community Development, and posted as a state lakes regulation;
(6) Owner. Any person, firm, association, partnership, municipality, county, or corporation owning, leasing, operating or having the exclusive use of a pier, structure or any property under a lease or otherwise;
(7) Private. The term private when applied to any permit, shall be deemed to mean that such permit shall be used for the primary enjoyment of the owner's family, personal guests, invitees, tenants or lessees. With private

permits, the owner may not collect any charge or fee for the use of any pier, boat, ramp or other structure which is the subject matter of the permit;

(8) Joint Private. The term joint private when applied to any permit means that the permitted structure is in joint ownership. Adjoining property owners who do not have sufficient land to meet the maximum measurement and limitations may apply for this permit. With joint private permits, the owners may not collect any charges or fees for the use of any pier, boat, ramp or other structure which is the subject matter of the permit. This term shall not be construed within the context of these regulations to mean any single family dwelling;

(9) Commercial. The term commercial when applied to any permit means that the permitted structure and activity shall be used primarily for gain or profit. This term shall not be construed within the context of these regulations to mean any single family dwelling;

(10) Permit. Any written permit issued by or under authority of the department, permitting the performance of a specified act or acts;

(11) Permittee. Any person to whom a permit is issued;

(12) Person. Any natural person, corporation, county, municipality, association, joint stock association, partnership or copartnership;

(13) Pier. The entire structure, including walkway, patio, platform, pavilion and boat stall;

(14) Walkway. The floored area of a pier excluding the patio, platform, pavilion and boat stall, used to egress and ingress on the pier;

(15) Pavilion. Any roofed structure erected above the floor level of a pier;

(16) Platform. Any floor area of a pier other than walkways, wherever located;

(17) Patio. Any floor area of a pier, whether covered or uncovered, which adjoins that shoreline of a land area of the owner's real property, not including walkways;

(18) Boat Stall. Any structure adjoining or attached to a pier which has the capacity to store one boat;

(19) Appliances. Any major electrical, gas, heating, or cooling device including, but not being limited to, refrigerators, stoves, heaters, freezers, air conditioners, or any other device or devices designed to be permanently situated or attached; Appliances shall not be construed to include lights or boats hoists:

(20) Transfer. Any devolution of title to or interest in water front property by deed, will, intestate succession, or otherwise by operation of any instrument or law;

(21) Boat Ramp. Any permanent or temporary structure which is placed on the floor of a state lake for the purpose of allowing boats to enter or be removed from a state lake; Boat ramp shall not be interpreted to mean boat stall;

(22) Lake Front Property. Any property adjoining or abutting upon a state lake.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976;
Amended Eff. April 4, 1979.

.0103 CONSTRUCTION

In the interpretations of North Carolina state lakes regulations, their provisions shall be construed as follows:

(1) Any terms in the singular shall include the plural.

(2) Any term in the masculine shall include the feminine and the neuter.

(3) Any requirement or prohibition of any act shall, respectively, extend to and include the causing or procuring, directly or indirectly, of such act.

(4) No provision hereof shall make unlawful any act necessarily performed by any officer or employee of the department in line of duty or work as such, or by any person, his agents or employees, in the proper and necessary execution of the terms of any agreement with the department.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0104 TERRITORIAL SCOPE

All North Carolina state lakes regulations shall be effective within and upon all state lakes in the State of North Carolina which are under the jurisdiction of the Department of Natural Resources and Community Development, and shall regulate the use thereof by all persons.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976;
Amended Eff. April 4, 1979.

.0105 PERMITS

A permit to do any act shall authorize the same only insofar as it may be performed in strict accordance with the terms and conditions thereof. Any violation by the permittee or employees of any term or condition thereof shall constitute grounds for its revocation by the department or by its authorized representative as provided for in Regulation .0310 of this Section. In case of such revocation of any permit, all monies paid for or on account thereof shall, at the option of the department, be forfeited to and be retained by it; and the permittee, together with his agents and employees who violated such terms and conditions, shall be jointly and severally liable to the department for all damages and loss suffered by it in excess of money so forfeited and retained; but neither such forfeiture and retention by the department of the whole or any part of such monies nor the recovery or collection thereby of such damages, or both, shall in any manner relieve such person or persons from liability of punishment under the statutes for any violation of any provision of any North Carolina state lakes regulation.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

SECTION .0200 - COMMERCIAL ENTERPRISES

.0201 COMMERCIAL ENTERPRISES

No person, being without a permit shall, in or upon any state lake or within or upon any structure on the floor of any state lake, sell or offer for sale, hire, lease or let out, any object of merchandise, property, privilege, service or any other thing, or engage in any business or erect any building or other structure whatsoever.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0202 SCIENTIFIC RESEARCH; EDUCATIONAL: NONCOMMERCIAL ACTIVITIES

No person shall engage in scientific, educational research, or other noncommercial activity in or upon a state lake without a special use permit issued by the Superintendent of State Parks. No such permit may be issued if the activity for which the permit is applied will have any adverse effect on the state lake or upon those who are engaging in any lawful activities thereon.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0203 COMMERICAL ACTIVITIES IN OR UPON STATE LAKES

No person shall engage in any commercial activity in or upon a state lake without a commercial activity permit issued by the Superintendent of State Parks. No such permit may be issued if the activity for which the permit is applied will have any adverse effect on the state lake or upon those who are engaging in any lawful activities thereon.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

SECTION .0300 - CONSTRUCTION AND USE OF PIERS AND OTHER STRUCTURES ON STATE LAKES

.0301 PERMITS

No pier, boat ramp, seawall, boat stall, pavilion, platform, patio, or other structure shall be built or maintained upon the floor of any state lake without a permit. After February 1, 1974, no pier, boat ramp, seawall, boat stall, pavilion, platform, patio or other structure, which requires a permit to be constructed initially, may be modified or enlarged so as to alter the design of the pier or other structure without first obtaining approval of the division based upon a Permit Amendment Application Form provided by the division. Such application shall be in accordance with Regulation .0309 of this Section. Such desired modification or enlargement must conform to the requirements of the regulations now in force. All such structures which were in existence on February 1, 1974, shall apply for a permit under these regulations. If the structure so existing conforms to the specifications governing size and otherwise, application may be made under the terms of Regulation .0311(1) of this Section. If the existing structure is not within the specifications as prescribed in these rules and regulations, application must be made under the terms of Regulation .0311(2) of this Section.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0302 STRUCTURES PROHIBITED ON CERTAIN STATE LAKES

No structures, except those owned by the department, shall be erected in or floating upon Singletary Lake, Jones Lake, and Salters Lake, nor in or floating upon those portions of any other state lake adjoining any land which is now or may later be owned or controlled by the department.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0303 PERMISSIBLE STRUCTURAL DIMENSIONS

Permits shall be approved for piers, boat ramps, boat stalls, pavilions, platforms, patios and other structures subject to the following limitations:

- (1) Commercial Piers. Maximum measurements for a commercial pier shall be as follows:
  - (a) walkways, 16 feet wide;
  - (b) length of pier structure, 375 feet;

(c) platform, pavilion; 32 feet in width;
(d) platform, pavilion; 50 feet in length;
(e) patio, 20 feet in length extending from mean high water mark.
(2) Private piers shall conform to the maximum requirements:
(a) Single family pier:
(i) walkways, 8 feet wide;
(ii) length of pier structure, 225 feet;
(iii) platform, pavilion: 20 feet in width;
(iv) platform, pavilion; 32 feet in length;
(v) patio, 20 feet in length extending from mean high water mark;
(b) Joint private piers shall be limited to the following maximum measurements:
(i) walkways, 16 feet wide;
(ii) length of pier structure, 225 feet;
(iii) platform, pavilion; 32 feet in width;
(iv) platform, pavilion, 50 feet in length;
(v) patio, 20 feet in length extending from mean high water mark.
(3) Public piers shall be subject to the following maximum measurements and limitations:
(a) walkway, 16 feet wide;
(b) length of pier structure, 225 feet;
(c) platform, pavilion; 32 feet in width;
(d) platform, pavilion; 50 feet in length;
(e) patio, 20 feet in length extending from mean high water mark.
(4) Boat Ramps. The maximum limitation for the size of a boat ramp will be 25 feet by 25 feet square; boat ramps shall not be subject to location criteria of Regulation .0303(6)(a) of this Section.
(5) Boat Stalls. There shall be a limit of one boat stall per single family pier. Boat stalls will not be permitted on joint private, public, or commercial piers.
(6) All permitted structures shall be subject to the following additional provisions:
(a) No structure or any portion thereof, except boat ramps, shall be located closer than 15 feet from the property owners' corners in the shoreline. Adjoining property owners who own waterfront property may, by special agreement, waive this provision in unusual or hardship cases, and where no hazard is erected by the waiver, may submit an application for a joint private pier permit.
(b) Piers must be located so as to point to a location fixed by the division.

(c) No pier, patio, platform, pavilion or boat stall may be located within 25 feet of another structure.

(d) Where an applicant fails to comply with these regulations because of the noncompliance of an adjoining property owner who holds a permit for a structure erected prior to the effective date of these regulations, the applicant shall submit his application for approval to the division. The division may approve the application subject to conditions and modifications it imposes in the permit.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0304 LIMITS ON EVELATED STRUCTURES

Maximum limits for structures of all types above the floor level of the pier, platform or patio shall be as follows:

(1) Overall structure height may not exceed 15 feet above the floor level of the pier, with the exception of flag poles, semaphores and light poles which may extend to a height of 20 feet above the first floor level.

(2) Storage boxes, lofts and compartments may be constructed on any pier so long as no equipment, materials or other property used in the construction of or stored in said storage areas shall be subject to combustion. All such structures must also provide for adequate ventilation. No electrical appliances may be installed within such boxes.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0305 PERMITS FOR STRUCTURES EXISTING AS OF FEBRUARY 1, 1974

(a) Owners of structures which presently meet the specifications of these regulations but were built under a valid permit and which were built according to the terms of that permit may legally continue under the old permit. Structures which were built without a permit or which were built under a permit but exceed the terms of the permit must apply for a new permit as in Regulation .0312 of this Section.

(b) Owners of structures which do not meet the specifications of these regulations including structures which were built without a permit or built under a legal permit but no longer meet the specifications of the permit and which structures, because of size or otherwise, are no longer eligible for a permit under these regulations must apply for a nonconforming use permit as described in Regulation .0312(1) of this Section. All such applications should be made to the Secretary of the Department of

Natural Resources and Community Development, Box 27687, Raleigh, North Carolina, 27611, on forms provided by the department. Such a permit when issued shall have the following conditions attached thereto; no alterations, enlargements or other structural modifications are permitted. Repairs to maintain the safety of the structure are allowed; should such structures be destroyed or substantially damaged (greater than 50 percent of replacement cost) from any causes, no replacement under the terms of the nonconforming use permit will be permitted. The owner of such structure may also agree that the Department of Natural Resources and Community Development, at the department's own expense, may bring the structure into compliance with these rules and regulations and therefore be eligible for an ordinary permit.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976;
Amended Eff. April 4, 1979.

.0306 FEES

The following schedule of fees shall be applicable to all structures beginning February 1, 1974, the payment of which shall be prerequisite to the rights and privileges exercised pursuant to these regulations and any and all permits issued pursuant thereto. Annual fees are due on May 1 of each year:

(1) Each application for the construction or placement of a new structure or the complete replacement of an existing structure, or the complete replacement of a structure for which a permit has previously been issued but which structure has been destroyed or removed by any means, shall be accompanied by an application fee of twenty dollars ($20.00) which is only refundable if the application is rejected.

(2) Applications for modifications or enlargement of an existing structure for which a valid permit is held by the applicant for modification or enlargement thereof shall be accompanied by an application fee of twenty dollars ($20.00) which shall be refundable only if the application is rejected.

(3) Application for renewal of a permit which was otherwise valid but which has been revoked for failure to pay the annual pier renewal fee within the time provided within 60 days after the due date thereof shall be acompanied by a renewal application fee of twenty dollars ($20.00), which shall only be refundable if the application is rejected.

(4) Transfer Fee. Applications for a transfer of a permit to the new owner of the waterfront property or the new owner of an interest in waterfront property giving rise to the

right of a permit under these regulations shall be accompanied by a transfer fee of ten dollars ($10.00), which shall not be refundable for any reason. This fee is not subject to being prorated and shall be paid in full without regard to the time of year at which the transfer occurred.

(5) Application for a nonconforming use permit shall be accompained by an application fee of fifty dollars ($50.00), which is not refundable for any reason.

(6) Annual fees:
- (a) private structures:
  - (i) piers not more than 50 feet in length -- five dollars ($5.00);
  - (ii) piers more than 50 feet in length but less than 101 feet in length -- ten dollars ($10.00);
  - (iii) piers more than 100 feet in length but less than 151 feet in length -- fifteen dollars ($15.00);
  - (iv) piers more than 150 feet in length -- twenty dollars ($20.00);
  - (v) boat ramps, boat mooring buoy -- five dollars ($5.00);
- (b) commercial structures:
  - (i) piers less than 226 feet in length -- twenty-five dollars ($25.00);
  - (ii) all piers more than 225 feet in length -- fifty dollars ($50.00);
  - (iii) boat ramps, boat mooring buoys -- twenty-five dollars ($25.00);
- (c) public structures -- ten dollars ($10.00).

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0307 CONDITION OF DOCKS, ETC.

All piers, boat ramps, seawalls, boathouses, pavilion, platform, patio or other structures on a state lake must without expense to the department be kept by the owner in a good state of repair and in a clean, sanitary, safe and presentable condition. Owners shall comply with all laws, rules and regulations now existing or hereafter adopted by the state and county departments of health. Owners shall also comply with all zoning regulations of the local town, municipality, or county. The provisions of this Regulation shall be subject to the notice and hearing procedures set forth in Regulation .0315 of this Section. At least one inspection of each structure shall be made annually by the division. Within 60 days of the date of inspection a notice of the results of such inspection shall be sent to the permit holder. This notice shall indicate either that the structure meets with the requirements of these regulations or if it does not shall specify:

(1) what problems are noted,
(2) what corrective actions are recommended.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0308 OBSERVANCE OF REGULATIONS

Owners shall abide by all the rules and regulations of the department and state statutes now in force or which hereafter may become operative.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0309 ELIGIBILITY FOR PERMITS

Permits to erect or attach structures except legal mooring buoys to the floor of any state lake, whether or not said structure shall also rise above the surface of the water thereof, shall be available only to the following classes of persons:

(1) owners of lands adjoining or abutting upon the waters;
(2) owners of an exclusive right to use lands having lake frontage, which lands are held by them for their exclusive use, held by them, or held by the record title owner of said property for the benefit of the owners of the right to use said lake front property;
(3) towns, municipalities or county governments at a public beach or at the end of a dedicated street.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0310 REVOCATION OF PERMITS

Permits granted pursuant to these regulations may be revoked for one or more of the following reasons:

(1) failure to pay any fee within 60 days after the due date thereof;
(2) failure to comply or to make provision to comply with the lawful order of any appropriate state park official concerning corrective measures to a structure deemed necessary by the department, within 30 days after receipt of a detailed notice setting forth in clear and unambiguous language the corrective measures deemed by the department to be necessary to bring the structure into compliance with these regulations, which notice shall

further contain reference to the regulation or regulations giving rise to the order to take corrective measures, and also giving notice as to his rights under Regulation .0315 of this Section, which notice shall be mailed by the division to the permit holder at both his lake address and his permanent address, if any, by certified mail, return receipt requested, postage prepaid by the department;

(3) failure to pay the permit transfer fee set forth in Regulation .0306 of this Section within 60 days after the date of the transfer of title to the waterfront property, or the transfer of the interest in waterfront property, which gives rise to the right to the permit;

(4) failure to comply with any rule or regulation herein or with any condition imposed on any permit issued.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0311 APPLICATION FOR STRUCTURAL PERMITS

Applications shall be made to the division of parks and recreation on standardized forms supplied by the division, and which shall include the following information: (to be submitted in tripicate)

(1) for initial permit, or permit for existing structure which meets these regulations:
  (a) a written description of a structure for which the permit is desired;
  (b) a drawing, photograph, diagram or other illustration adequately depicting the structure for which the permit is desired, and which drawing, photograph, diagram or other illustration locates the structure relative to the waterfront property which gives rise to the right to apply for the permit sufficient to meet the requirements of Regulation .0303 of this Section;
  (c) a statement identifying the waterfront lands to which the structure is to be attached, or if the structure is not to be attached to the waterfront property at the water line, the waterfront property which gives rise to the right to apply for the permit. A map or plat of the waterfront property will suffice for this identifying statement; Such maps are highly desirable;
  (d) a statement of applicant's ownership of or property right in the waterfront lands giving rise to the right to apply for the permit;
  (e) a statement that the applicant has read and understands these regulations and that to the best of his knowledge and belief all of the statements contained in this

application are true in accordance with these regulations;

- (f) a statement of the applicant's full name, and his or her lake and permanent address;
- (g) such other information as the division may include in said application which is reasonably related to the administration of these regulations and the furtherance of the purposes of these regulations set forth above;

(2) applications for amendment of a permit for modification or enlargement for a structure:

- (a) a written description of the structure for which the amended permit is desired, describing the modification and/or enlargement to be made to the structure;
- (b) a drawing, photograph, diagram or other illustration adequately depicting the modifications and/or enlargements for which the amended permit is desired, and locating the proposed modifications and/or enlargements with respect to the existing structure and the waterfront property giving rise to the initial permit; which shall be sufficient to conform to the requirements of Regulation .0303 of this Section;
- (c) a statement setting forth any changes in applicant's ownership or property interest in the waterfront lands giving rise to the initial permit and the application for an amended permit which have occurred since the date of the application for the initial permit, if any;
- (d) a statement that the applicant has read and understands these regulations as of the date of the filing of the application for an amended permit and that to the best of his knowledge and belief all of the statements contained in this application are true in accordance with these regulations;
- (e) such other information as the division may include in said application which is reasonably related to the administration of these regulations and the furtherance of the purposes of these regulations set forth above;

(3) Applications for transfer of a permit (to be made by transferee):

- (a) a statement of the name or names of the transferee or transferees, together with their permanent home address and their lake address;
- (b) the name and address of transferor of the permit;
- (c) the permit number or other identifying mark of the division of parks and recreation by which the permit is identified;
- (d) evidence of the conveyance, devise, or other mode of transfer of title to the property giving rise to the

right to the permit; For example, but not by way of limitation, a copy of the deed of conveyance, copy of will, or reference to the place of recording in the public registry in the county in which the property is situated where written evidence of the transfer may be found;

(e) such other information as the division may include in said application which is reasonably related to the administration of these regulations and the furtherance of the purposes of these regulations set forth above.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0312 PERMITS FOR STRUCTURES EXISTING ON FEBRUARY 1, 1974

(a) For structures meeting the specifications of these rules and regulations; Application for structures under these conditions may be made as under Regulation No. 0311 (1) of this Section.

(b) For structures which do not meet the specifications of these rules and regulations; These applications for a nonconforming use permit should be made directly to the Secretary of the Department of Natural Resources and Community Development, Box 27687, Raleigh, North Carolina, 27611, on standardized forms supplied by the department. The information supplied shall include the following:

(1) The date construction was initiated on the structure;
(2) List nonconforming specifications;
(3) See .0311(1)(a) of this Section;
(4) See .0311(1)(b) of this Section;
(5) See .0311(1)(c) of this Section;
(6) See .0311(1)(d) of this Section;
(7) See .0311(1)(e) of this Section;
(8) See .0311(1)(f) of this Section;
(9) See .0311(1)(g) of this Section.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976;
Amended Eff. April 4, 1979.

.0313 LIABILITY

Neither the state nor the department nor any of its employees shall be held liable in any claims arising from damage to person or property in the use by permittee or by the public of structures on the state lakes.

History Note: Statutory Authority G.S. 113-35;

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0314 RIGHT OF ENTRY RESERVED

The department reserves to itself through its authorized officers the right of entry upon any pier, ramp or other structure held by the permittee to inspect the same at reasonable times for the purpose of seeing that the regulations are being carried out and that the permittee is conducting his operation or his use and occupancy in conformity with these regulations. The permittee, by holding or requesting a pier permit grants to the department the right to land access to the pier, ramp or other structure for the purpose of inspection of the pier.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0315 NOTICES, RIGHT TO HEARING, HEARING PROCEDURES, APPEAL

Prior to the exercise by the department of the right of revocation of a permit under any regulation other than Regulation .0306 of this Section, or denial of application for a structural permit, the department shall give written notice of its intention to revoke the permit upon the failure of permit holder to do and perform, or to refrain from doing or performing the things described in detail in said notice or reasons for denial of said permit application. In the case of failure to comply with Regulation .0306 of this Section regarding payment of fees, revocation of a permit is automatic. However, no further action shall be taken under Regulation .0105 or Regulation .0310 of this Subchapter until the permit holder shall be notified in writing by the division, which notice shall contain at least the following:

(1) Notices, Rights to Hearing, Right to Appeal, Initial Hearing Procedures. The notice shall contain:
  (a) a statement of the regulation or regulations under which the department purports to be acting in revoking or stating its intention to revoke the permit or for denial of said permit application;
  (b) a statement in clear and unambiguous terms of the thing or things which the department contends are in violation of these regulations, and if the alleged violations are capable of correction under these regulations, the action which the department contends is necessary to bring the permit holder into compliance with these regulations;
  (c) the date on which the revocation will be made final if the permit holder does not call for a hearing as hereinafter provided, which final date of revocation

shall not be sooner than the 31st day after the date of receipt of the notice by the permit holder as evidenced by the U.S. Postal Service return receipt showing the date upon which the notice was received by the permit holder;

(d) the action proposed to be taken by the department, if any, in addition to revocation of the permit;

(e) a statement that the permit holder has the right to call for a hearing prior to the revocation of the permit and prior to the taking of any other action by the department if the permit holder files, in writing, not later than 30 days after the date of delivery of the notice to him as evidenced by the date of delivery shown on the U.S. Postal Service return receipt applicable to said notice; A similar statement shall be sent in case of a permit application denial. The permit holder's notice to the department shall be sent to Park Superintendent, Singletary Lake Group Camp, Route 1, Box 63, Kelly, North Carolina, 28448. This notice shall be in writing and shall preferably be delivered by certified mail, return receipt requested. If said notice shall be delivered in person, the date marked thereon by the division officer receiving same shall be deemed to be the date of both the giving of notice by the permit holder and the receiving of notice by the division;

(f) a statement that upon the receipt of notice by the department of a demand for hearing as set forth in this Rule, the division of parks and recreation will conduct a hearing into the matter of the proposed revocation, permit denial, or other order of the department on a day and date selected by the division not later than 60 days after the date of its receipt of the notice of demand for a hearing; The hearing shall be at Singletary Lake Group Camp in Bladen County, North Carolina, or at such other reasonable place determined by the division, including, but not being limited to, a place near the location of the property owned by the permit holder or permit applicant and to which the permit in question is applicable, for the convenience of all parties interested therein and especially where a possible view of the premises may be involved. The division should endeavor, but shall not be required, to consult with the permit holder or permit applicant who has called for a hearing to determine the mutually most convenient day, date and site for the hearing. Upon agreement of the parties in writing, the hearing may be set for any place and time agreed to by the parties not later than 60 days following the date of the receipt of notice of the call for a hearing from the permit holder by the division;

(g) a statement that the permit holder or permit applicant may appear in person and testify, that he may present witnesses on his behalf, that he may examine and cross-examine the officials of the division upon whose recommendation and authority the proposed revocation or other order was made, that the permit holder or applicant may be represented by counsel of his choice, that the permit holder or applicant may have access to any documentary and other information in the file of the division applicable to his permit and structure, and any and all documents, reports, notes, photographs, or other written, photographic or visual evidence relative to the permit and structure owned by the permit holder;

(h) a statement that the permit holder or applicant has a right of appeal from the decision of the division to the Secretary of the Department of Natural Resources and Community Development; The division must prepare a written record of the proceedings including its findings of fact and conclusion of law. These findings and conclusions must be based on substantial evidence viewing the record as a whole.

(2) Procedures on Appeal. A person aggrieved by a decision of the division may within 10 days of notice of the decision of the division file notice of appeal to the secretary of the department. The aggrieved party may submit at any time within 10 days of date set for the appellate hearings its own proposed findings of fact and conclusions of law plus any supporting briefs it deems necessary and relevant. The hearing shall be before the secretary or his specifically designated hearing officer and shall consist solely of oral arguments of the parties or their representatives. No additional evidence shall be permitted unless the prior submitted brief indicates that relevant evidence was specifically excluded at the division hearing. This contention must be supported by a direct proffer and exclusion of such evidence. If a hearing officer has been designated, he shall submit to the secretary the following record and material: The record of the division hearing, the findings, fact, and conclusions of law of the division, the proposed findings of fact and conclusions of law submitted by the aggrieved party prior to the appellate hearing, all briefs submitted

prior to the appellate hearing, the record of the appellate hearing and finally the proposed findings of fact and conclusions of law of the hearing officer. On the basis of this comprehensive record, the secretary shall, after consultation with the Parks and Recreation Council, reach the final department decision. The secretary's decision shall be final, in writing and based upon the complete record upon substantial evidence looking to the record as a whole. The decision shall be mailed to all parties by registered mail, return receipt requested and shall be effective upon receipt.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976;
Amended Eff. April 4, 1979.

.0316 ENFORCEMENT

(a) Criminal Penalties. Any violations of these regulations shall constitute a misdeameanor and shall be punishable by a fine of not more than fifty dollars ($50.00) or by imprisonment for not exceeding 30 days.

(b) Civil Penalties. Any structure built or present on a state lake without a permit is defined by General Statutes 146-13 as a nuisance. As such it is subject to abatement or removal after due process of law.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

SECTION .0400 - MISCELLANEOUS STATE LAKES REGULATIONS

.0401 DISPOSAL OF REFUSE, GARBAGE, ETC.

No person shall throw, cast, lay, drop, or discharge into or leave in any state lake any building material, gasoline, oil, grease, oily water, garbage, offal, sewerage, refuse, waste, fruits, vegetables, foodstuffs, boxes, paper, glass, tin cans, razor blades or other waste materials.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0402 HUNTING

No person shall hunt, pursue, trap, shoot, injure, kill, or molest in any way any bird or animal in, upon, or over any state lake.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0403 FIREARMS

No person except authorized employees and officers of the department and bona fide peace officers on official duty shall carry, possess or discharge firearms of any description, spearguns, or airguns, in or upon any state lake.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0404 EXPLOSIVES

No person shall bring into or have in or upon any state lake any explosive or explosive substance.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0405 AVIATION

No person shall voluntarily bring, land or cause to descend or alight within or upon any state lake, any airplane, flying machine, balloon, parachute or other apparatus for aviation, except under permit issued by the Superintendent of State Parks and then only in duly marked or designated landing areas. Voluntarily in this connection shall mean anything other than a forced landing.

History Note: Statutory Authority G.S. 113-35;

Eff. February 1, 1976.

.0406 WATER LEVEL

No person shall in any way damage or alter drainage ditches, drainage gates or any other inlet or outlet from a state lake; nor in any way change the water level of a state lake. Water level for purpose of measuring the depth of water in the lake shall be determined by the department.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0407 MOORING BUOYS

No stakes, poles or posts, shall be driven or placed into the floor of any state lake for any purpose, except to anchor a lawfully placed mooring buoy. Mooring buoys may be placed upon the floor of state lakes for the purpose of mooring boats by permits issued by the division. Mooring buoys placed upon state lakes shall meet the requirements of the Wildlife Resources Commission State Boating Regulations. No mooring buoy may be placed outside any established safety zone, or 375 feet from shore where there is no established safety zone. Where the permittee is an owner the buoy may be placed at any point within the safety zone. Where the permittee is not an owner, the buoy may not be placed within 25 feet of any structure or within 100 feet of the shore. However, in no case may a mooring buoy be placed within 25 feet of another legally permitted buoy. The division may authorize the placement of bucys for recreational purposes. The division is to cooperate, whenever possible, with clubs, groups and other organizations seeking to promote or offer organized recreational activities or shows or tournaments.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0408 STATE PARKS REGULATIONS

In addition to the North Carolina State Lakes regulations, the North Carolina State Park and Recreation Area regulations shall apply to Jones Lake, Phelps Lake, Salters Lake, Singletary Lake and those portions of any other state lakes adjoining any land which is now or may later be owned or controlled by the department.

History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976.

.0409 INFORMATION

Information concerning state lakes regulations may be obtained by contacting the division of parks and recreation:

(1) Superintendent
Singletary Lake
Route 1, Box 63
Kelly, North Carolina 28448

(2) Superintendent of State Parks
Division of Parks and Recreation
Department of Natural Resources
and Community Development
P.O. Box 27687
Raleigh, North Carolina 27611

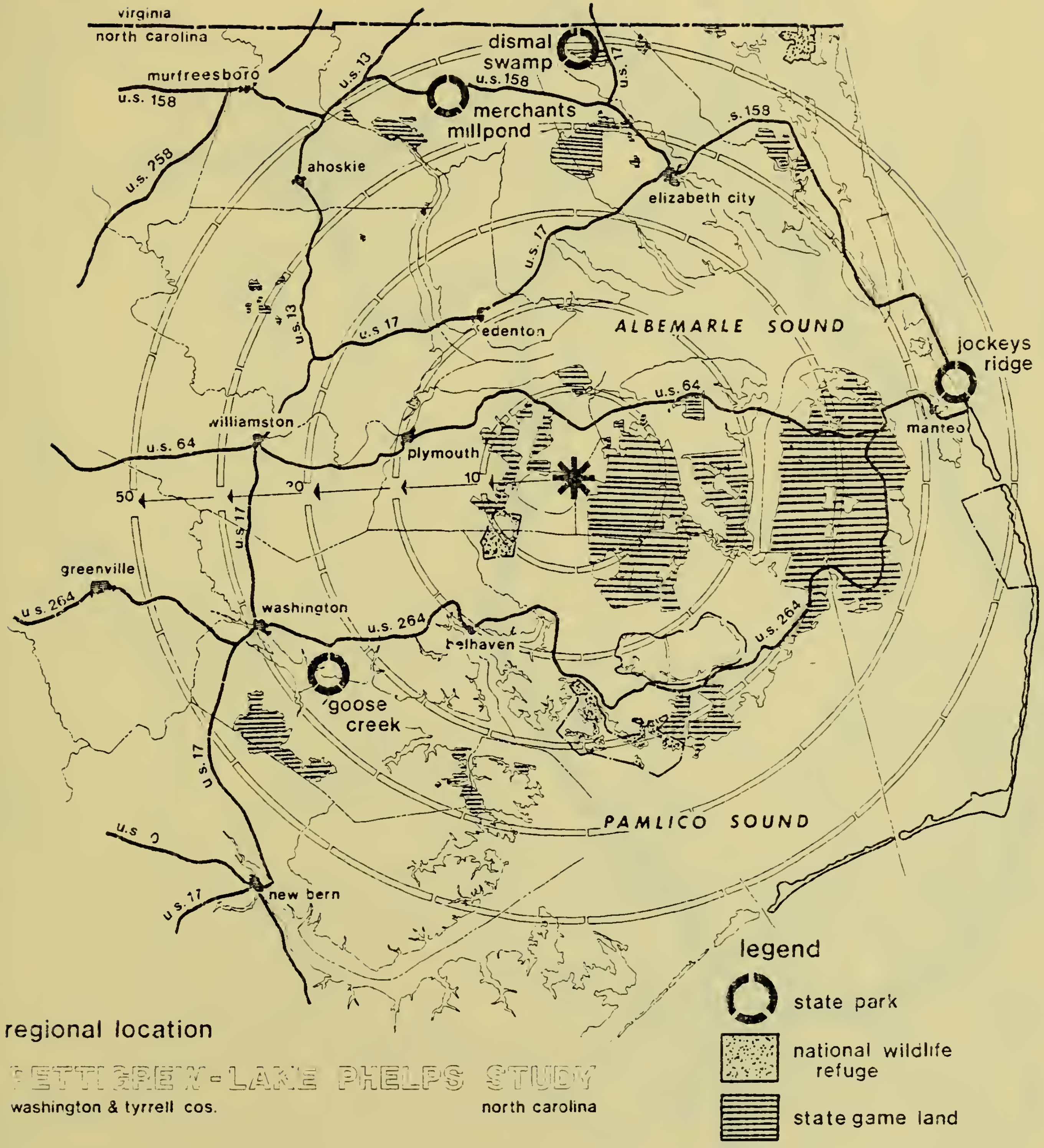
History Note: Statutory Authority G.S. 113-35;
Eff. February 1, 1976;
Amended Eff. April 4, 1979.

PART G.

APPENDICES

APPENDIX

Figures



regional location

PETTIGREW-LAKE PHELPS STUDY

washington & tyrrell cos.
north carolina

Figure A-1

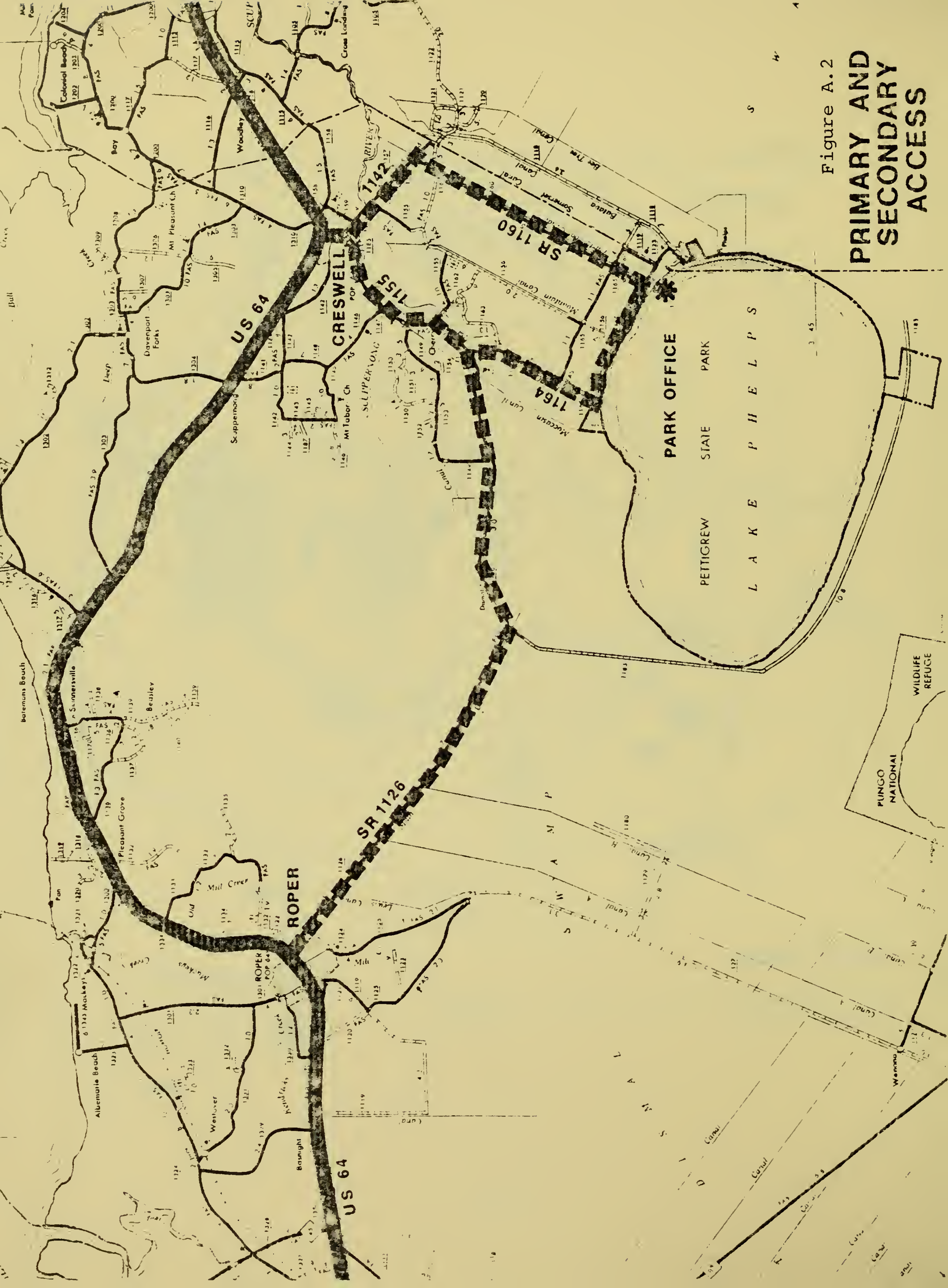
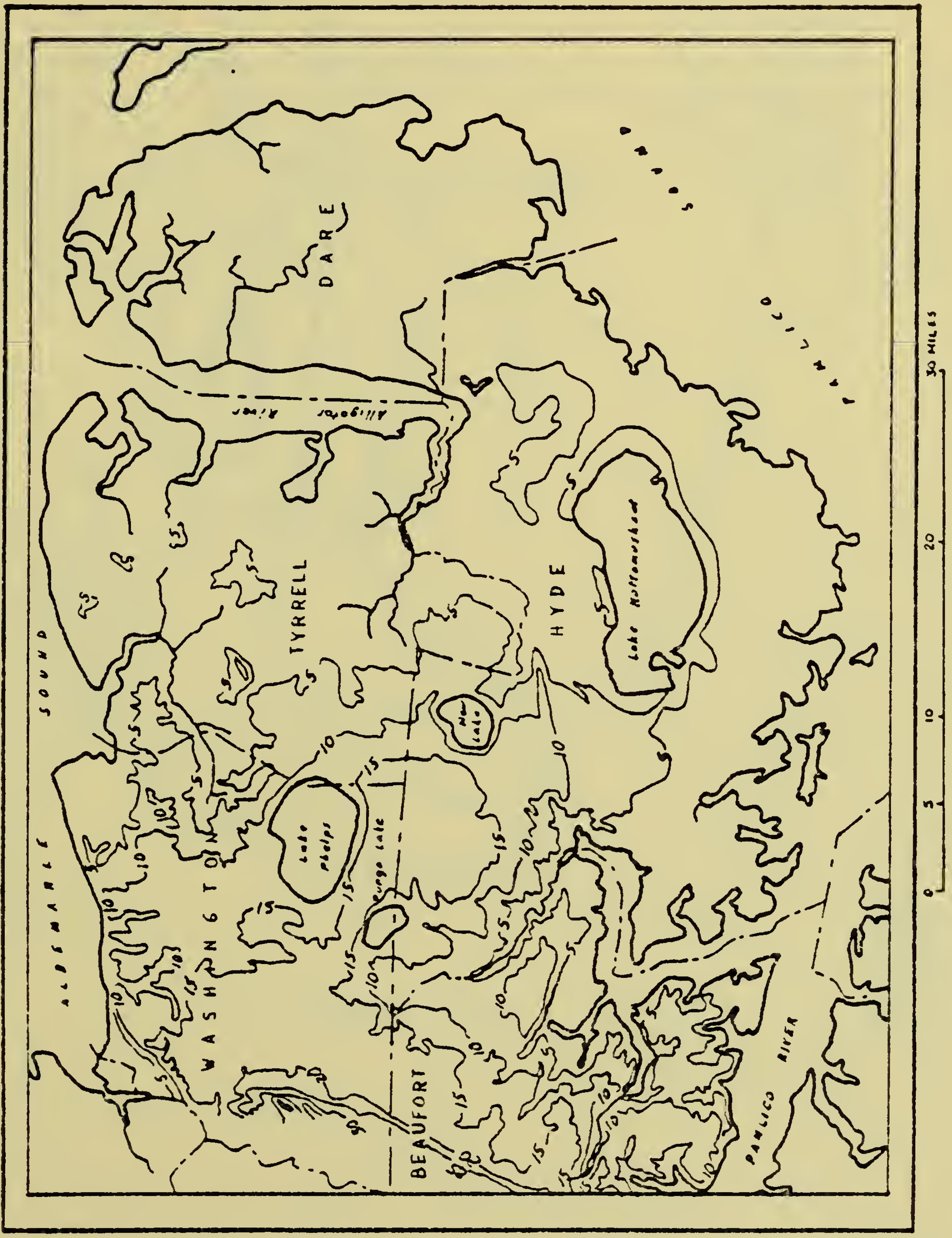
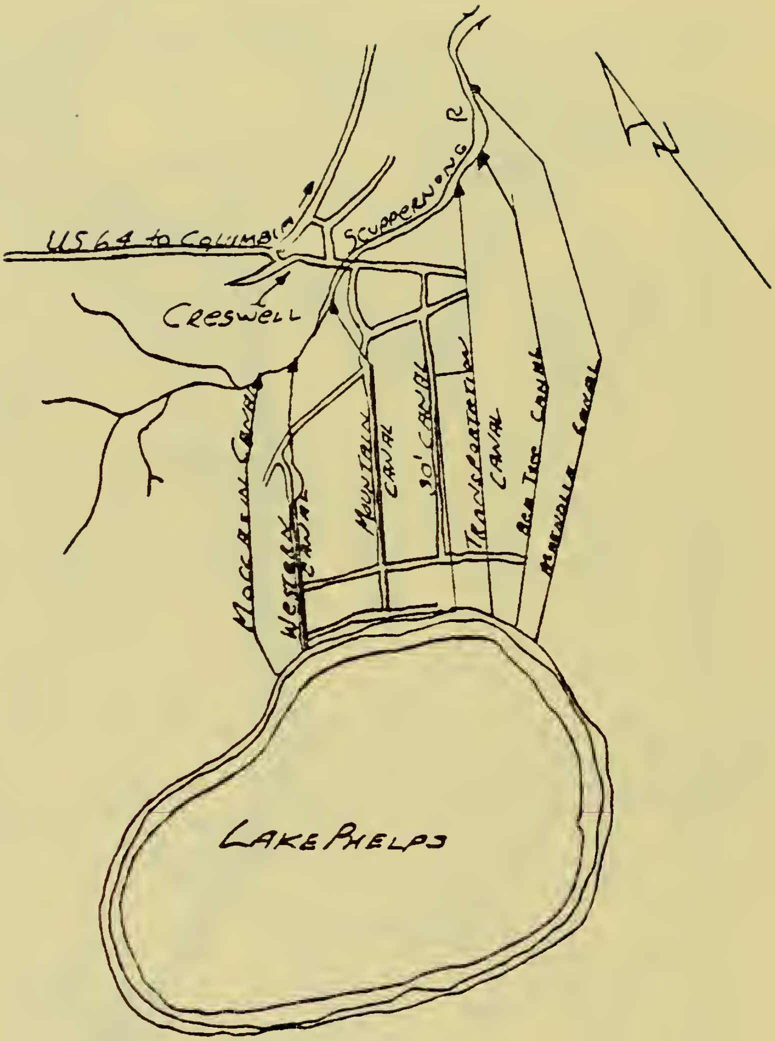


Figure A.2
PRIMARY AND SECONDARY ACCESS



TOPOGRAPHY

Figure A.3



CANAL LOCATION MAP

Figure A.4

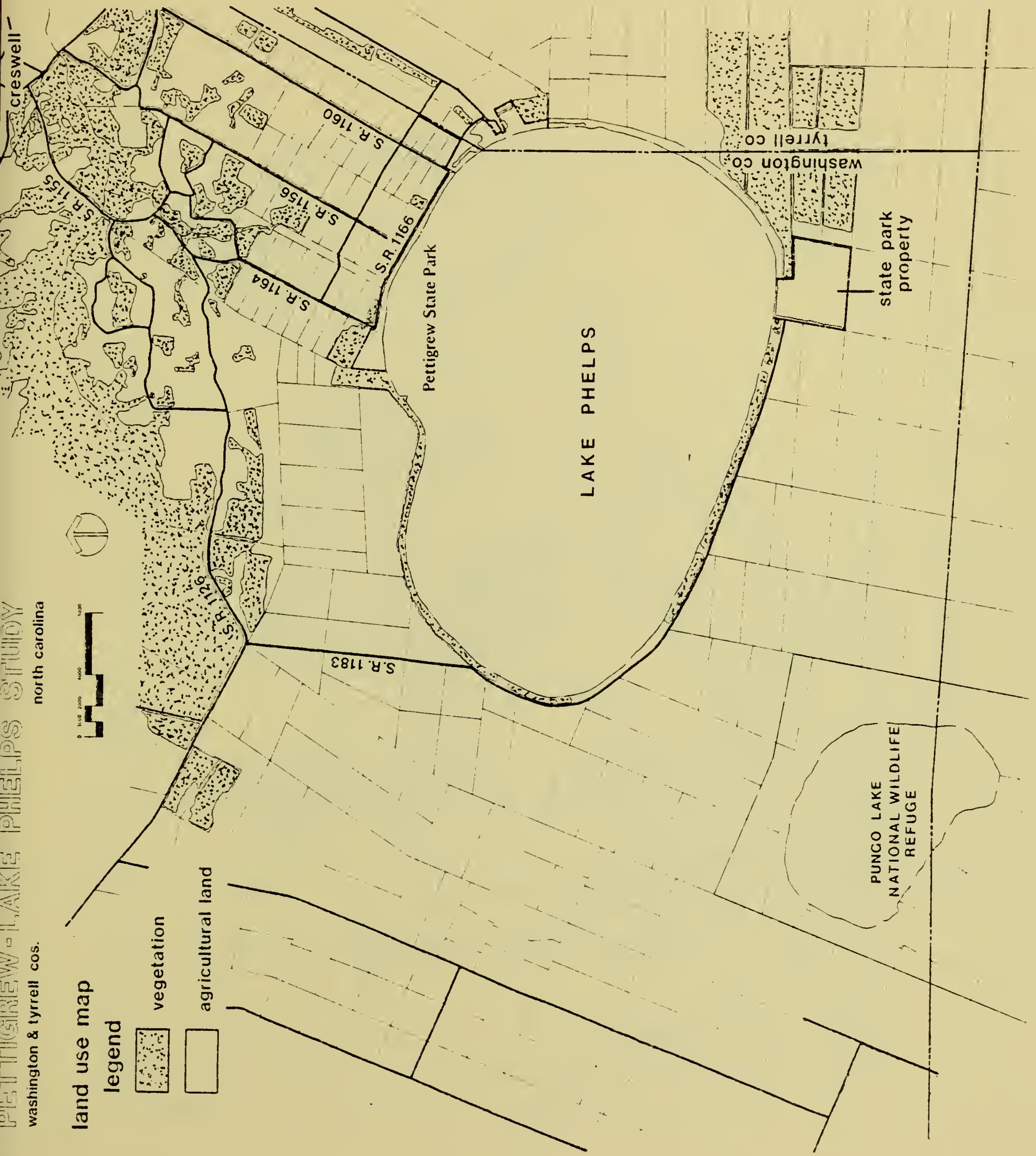
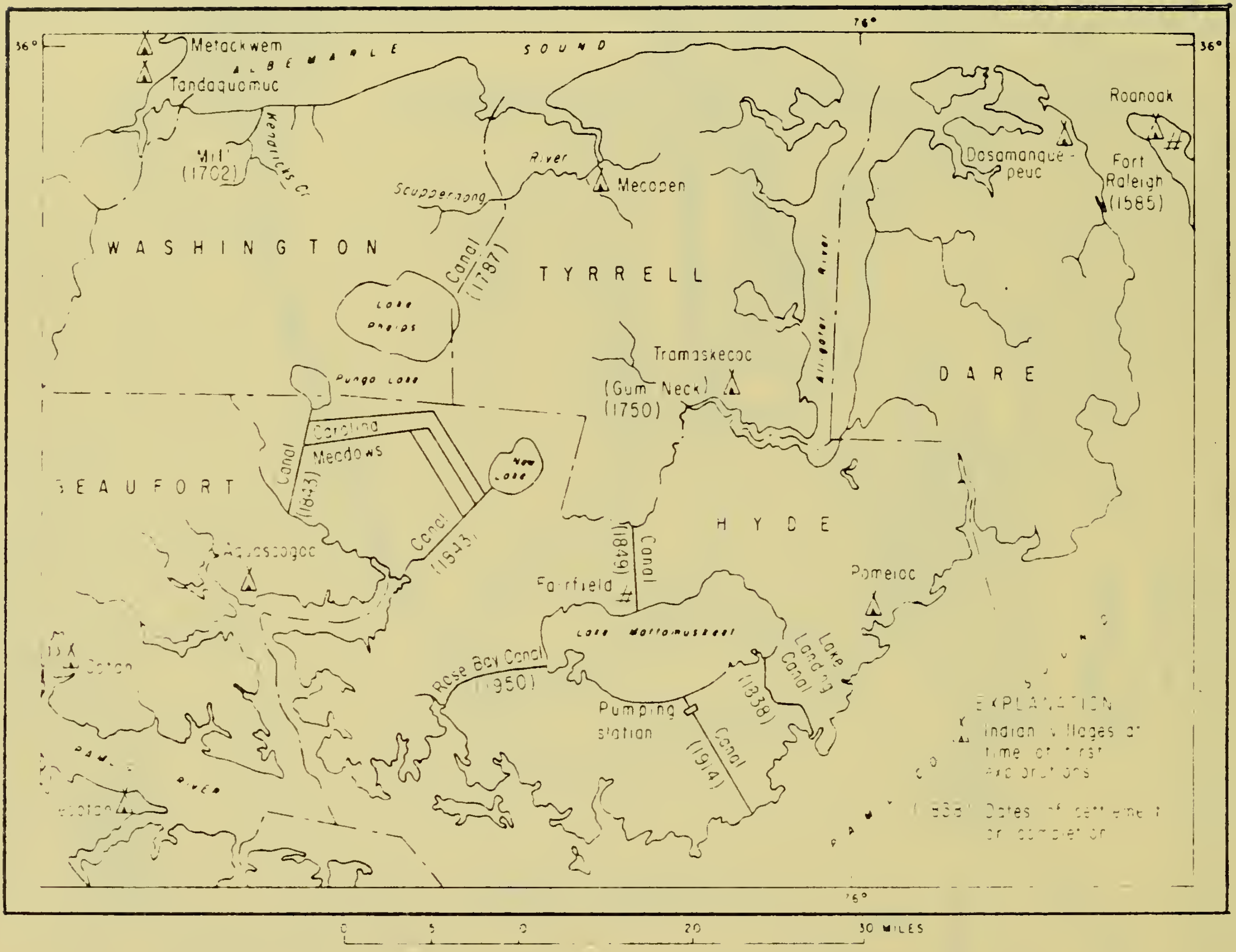
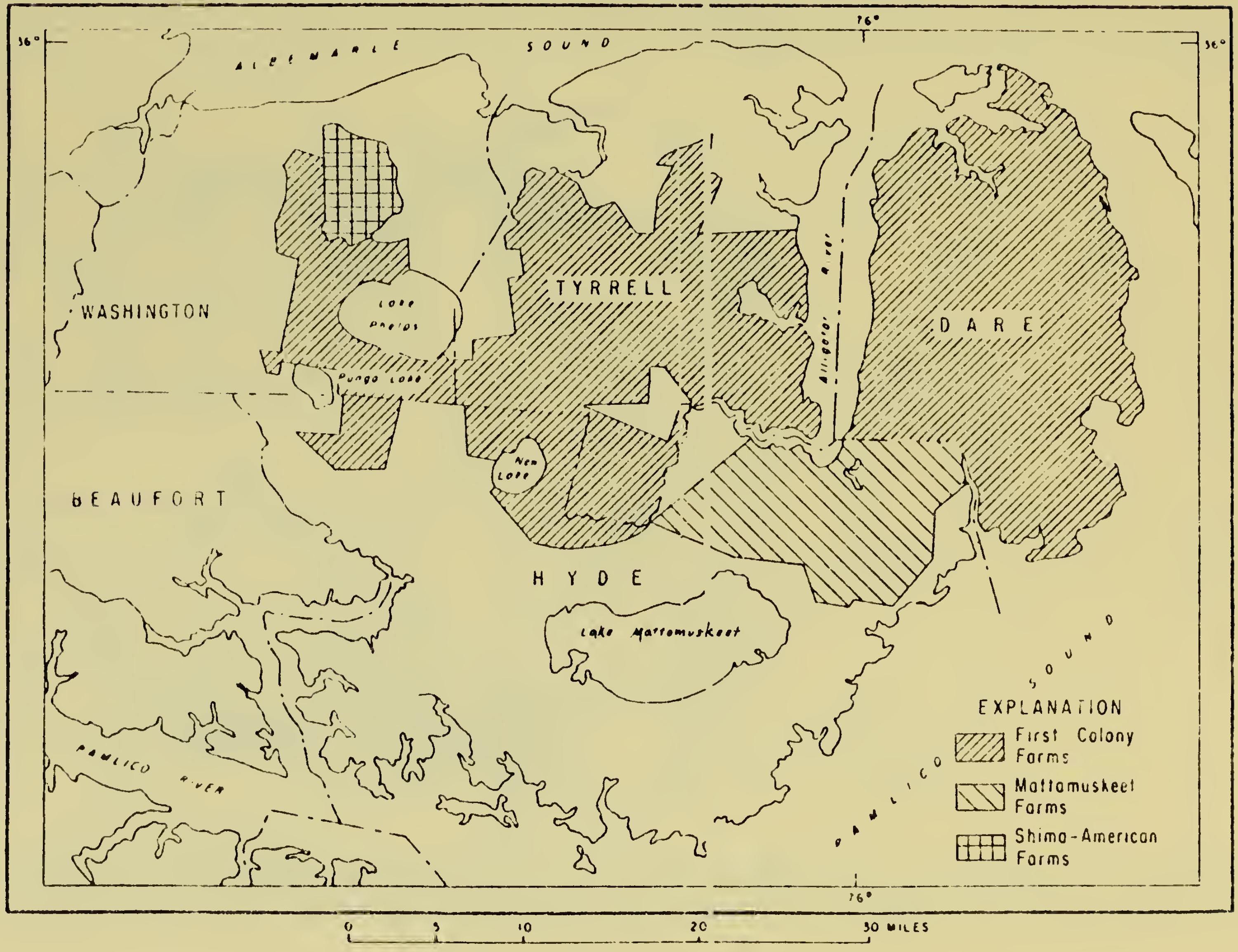

PETTIGREW-LAKE PHELPS STUDY
washington & tyrrell cos.
north carolina
land use map
legend
vegetation
agricultural land
creswell
S.R. 1155
S.R. 1160
S.R. 1156
S.R. 1164
S.R. 1166
Pettigrew State Park
LAKE PHELPS
S.R. 1126
S.R. 1183
tyrrell co
washington co
state park property
PUNCO LAKE NATIONAL WILDLIFE REFUGE

Figure A.5



EARLY SETTLEMENTS AND MAN-MADE WORKS

Figure A.6



Land owned by large corporate farms in 1974.

Figure A.7

CULTIVATED LAND - 1938

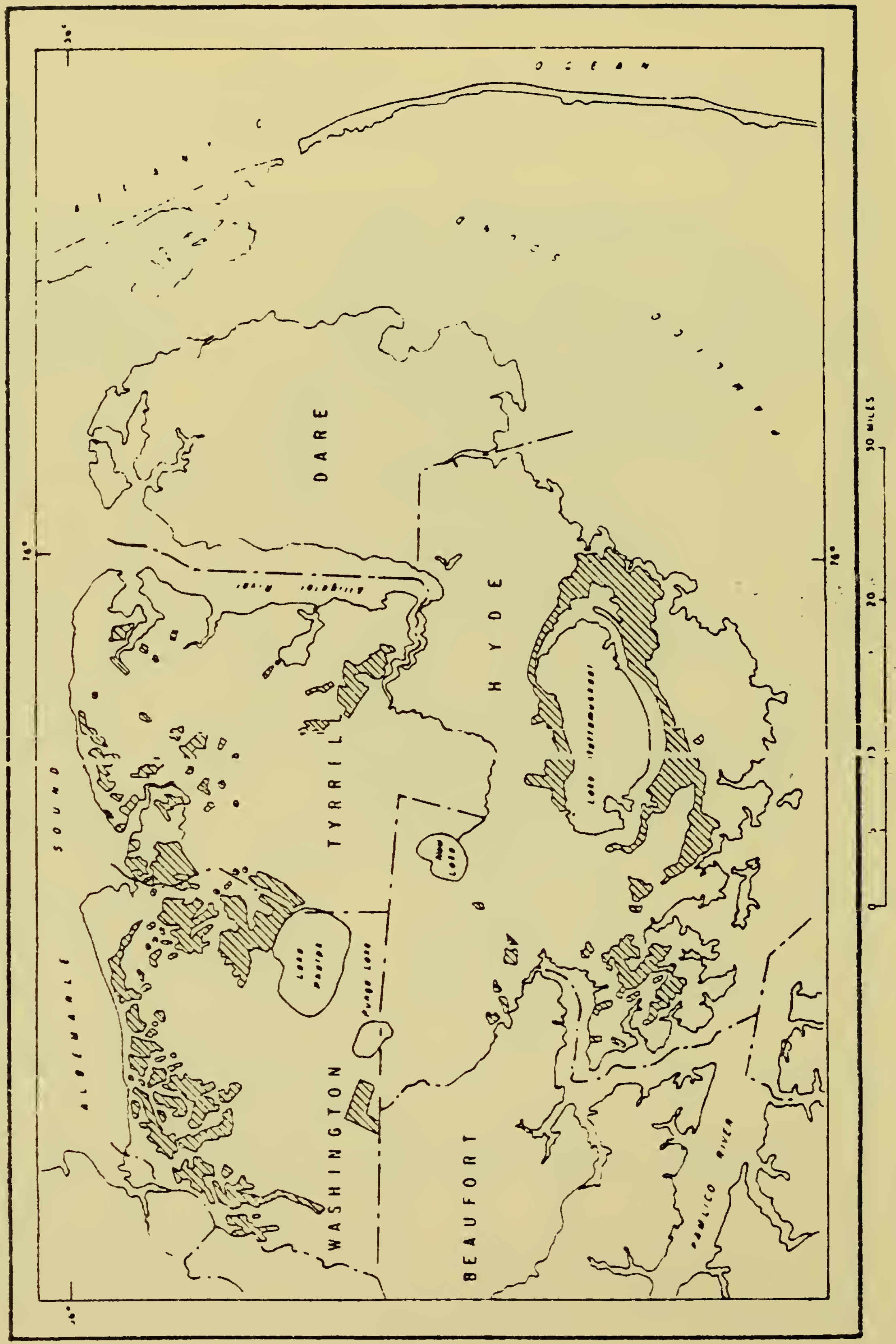


Figure A.8

CULTIVATED LAND - 1956

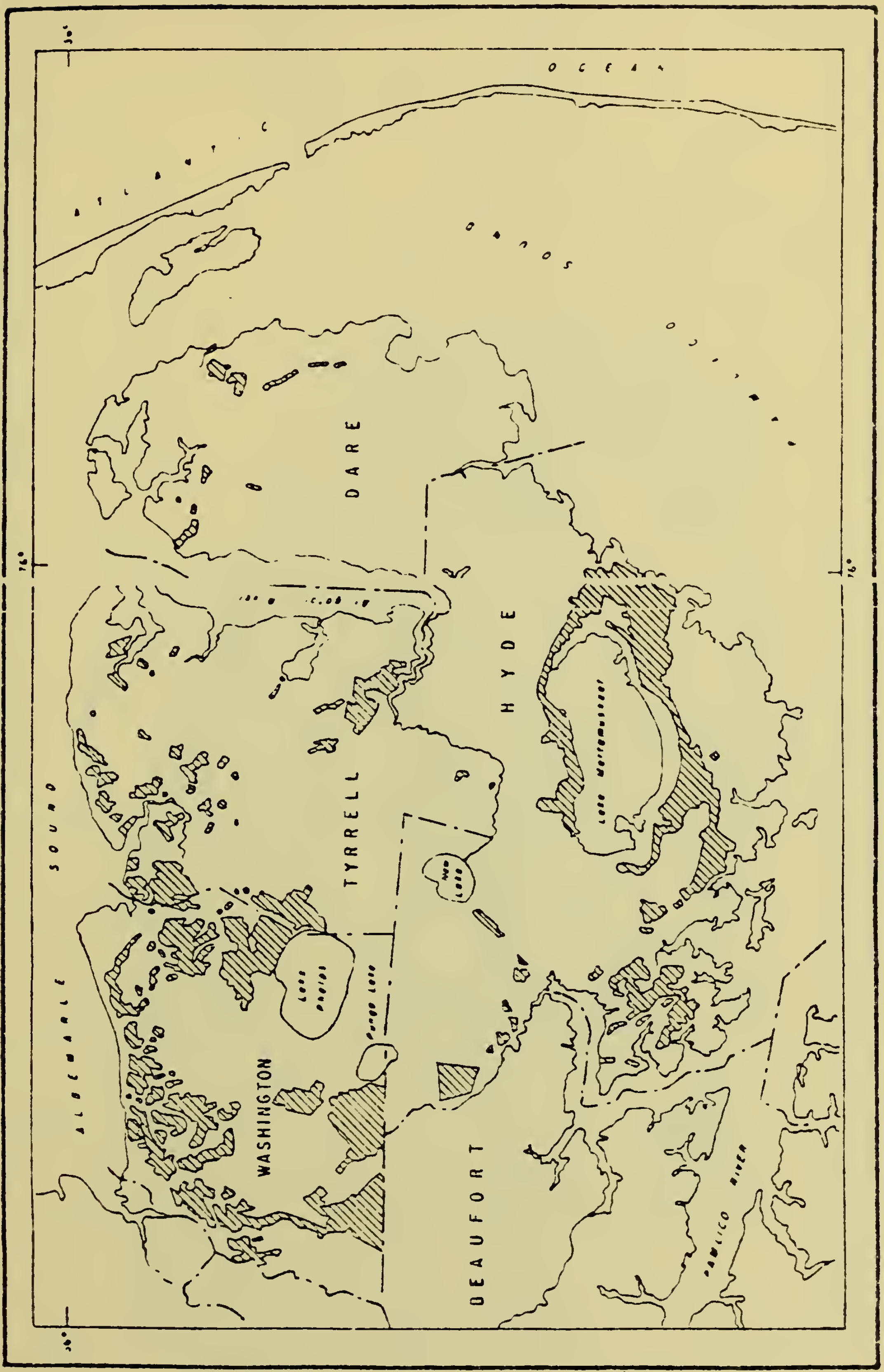


Figure A.9

CULTIVATED LAND PROJECTED TO 1980

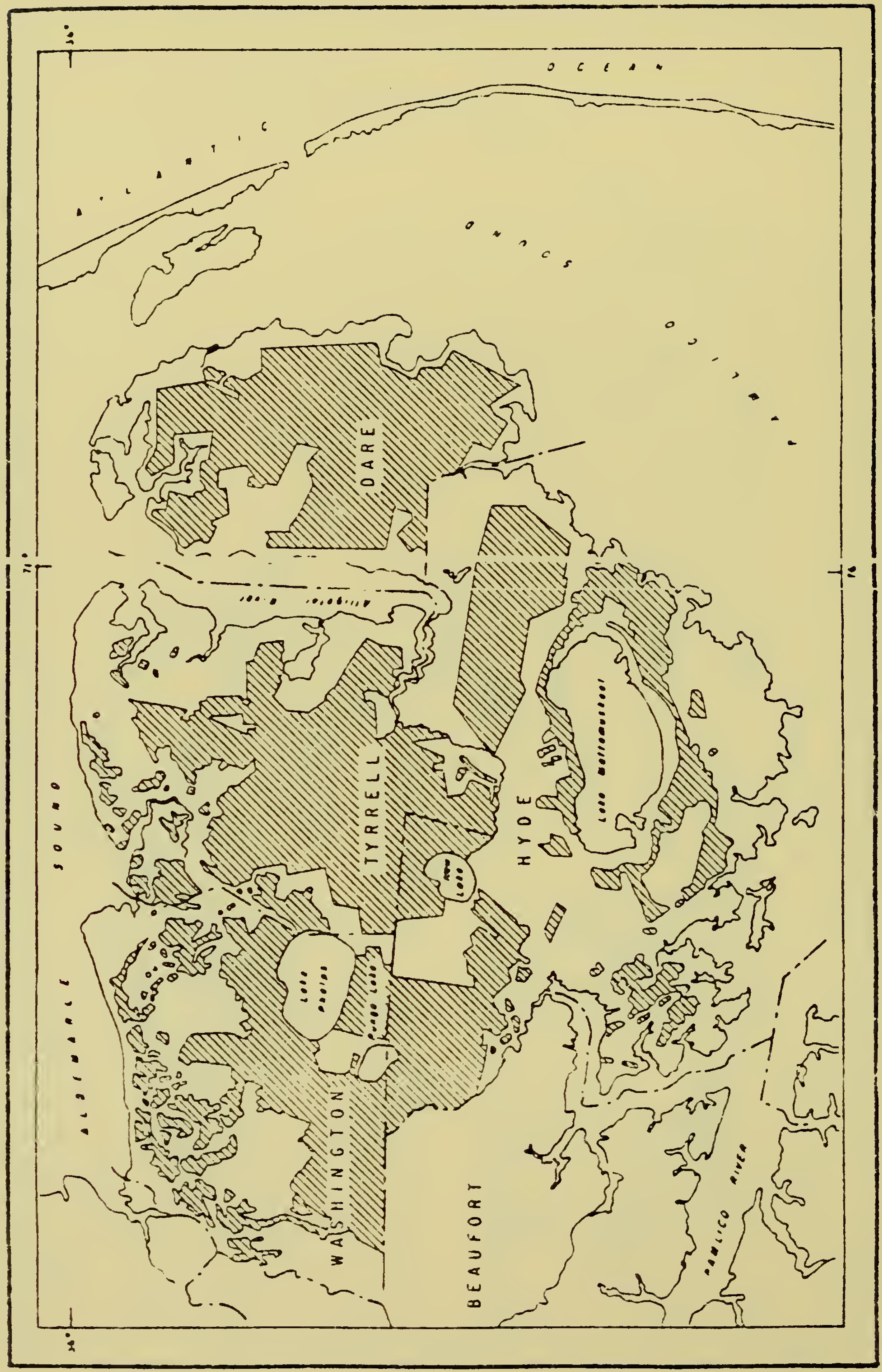


Figure A.10

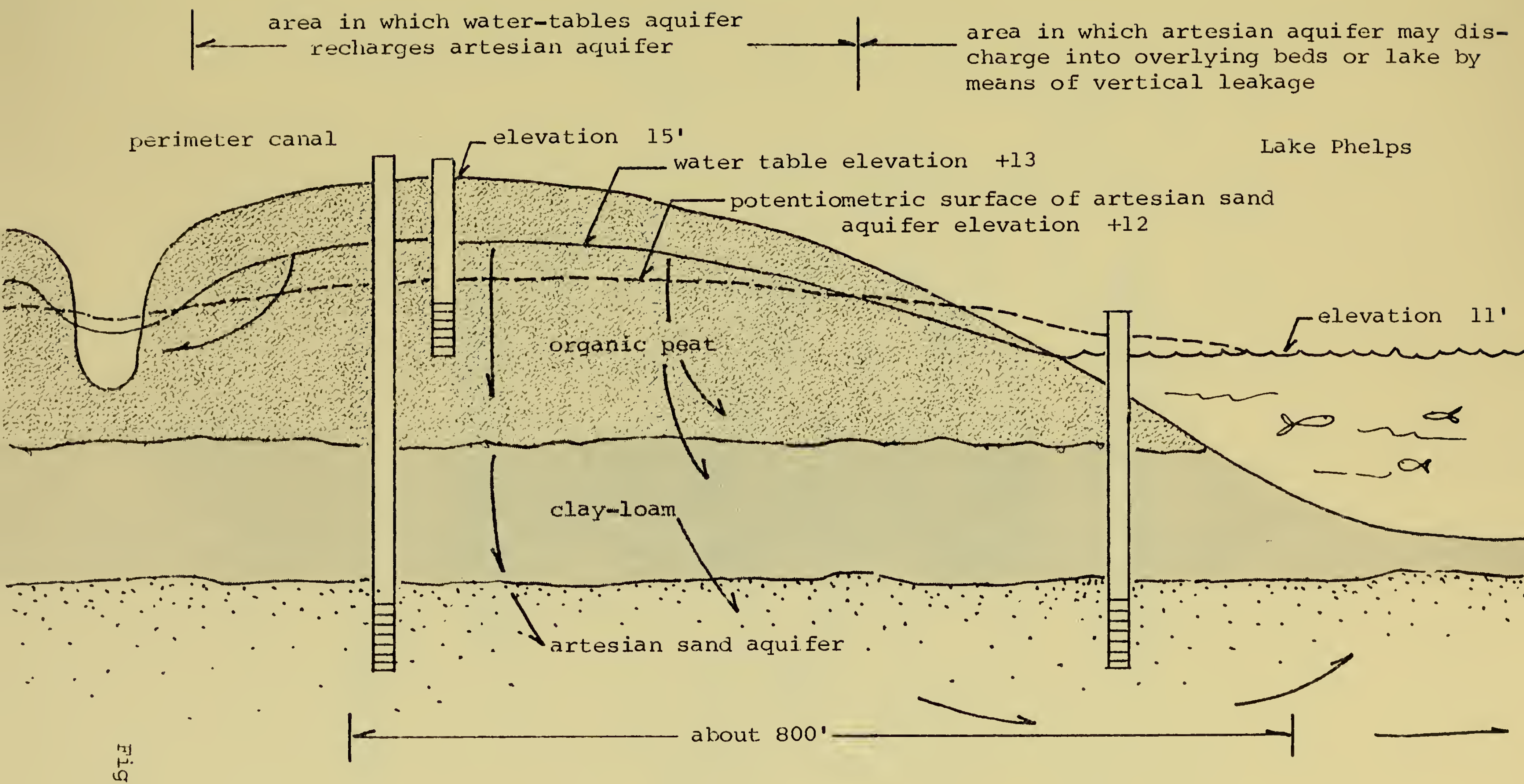
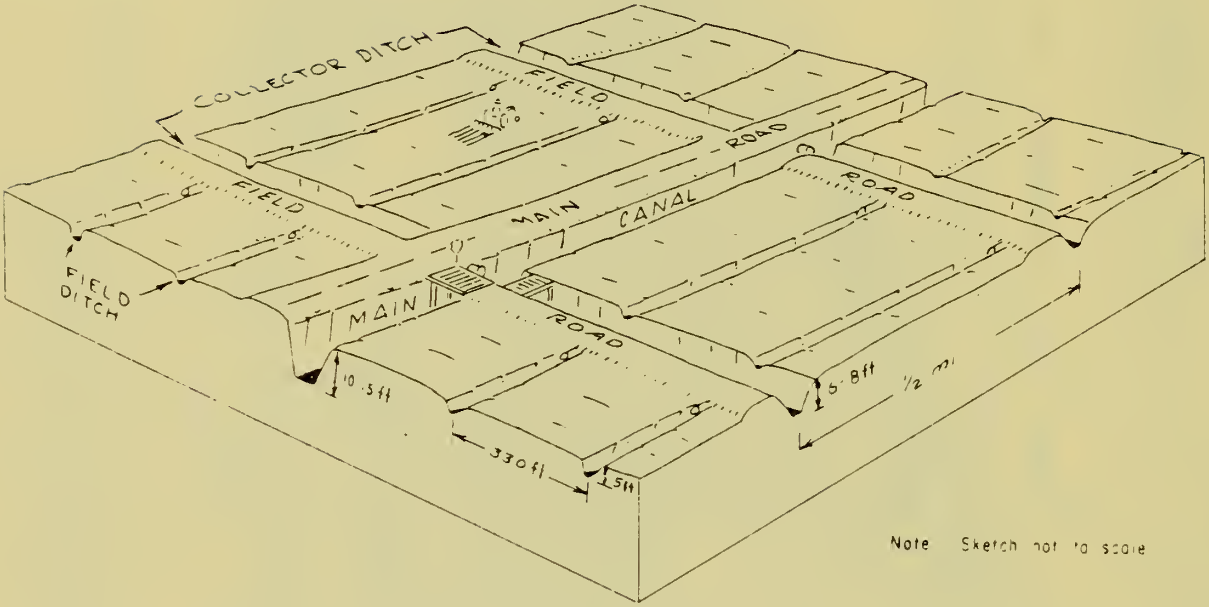

area in which water-tables aquifer recharges artesian aquifer
area in which artesian aquifer may discharge into overlying beds or lake by means of vertical leakage
perimeter canal
elevation 15'
water table elevation +13
potentiometric surface of artesian sand aquifer elevation +12
Lake Phelps
elevation 11'
organic peat
clay-loam
artesian sand aquifer
about 800'
Not to Scale
S
N

Figure A.11

south-north cross-section
south shore Lake Phelps

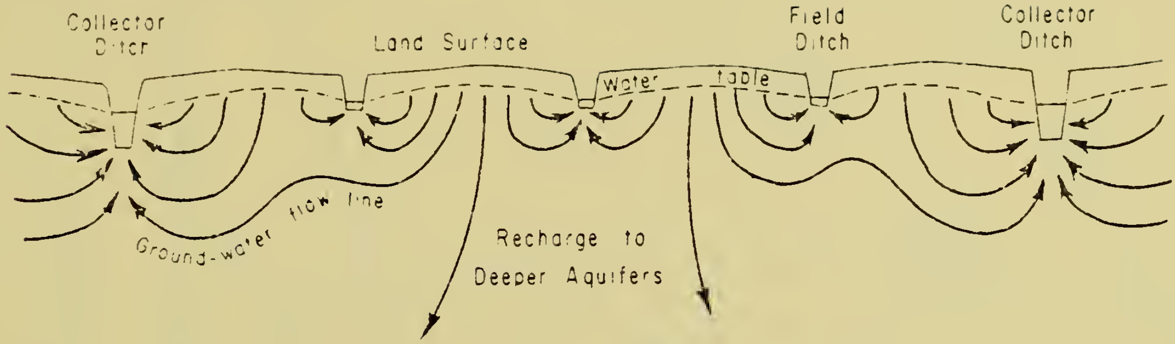
ARTIFICIAL DRAINAGE SYSTEM



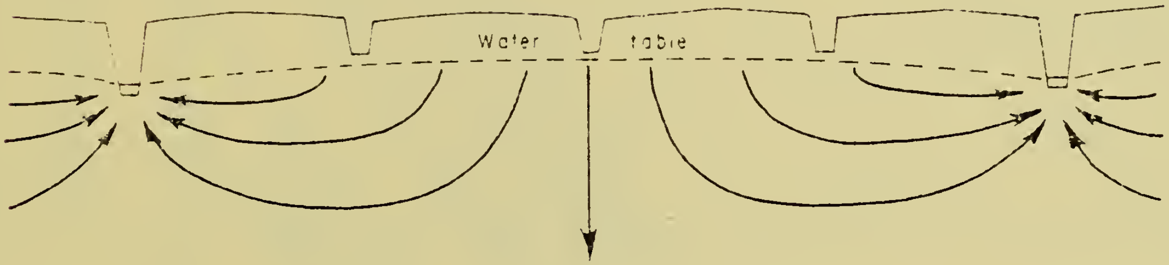
Note Sketch not to scale

Figure A.12

WINTER AND SPRING CONDITIONS

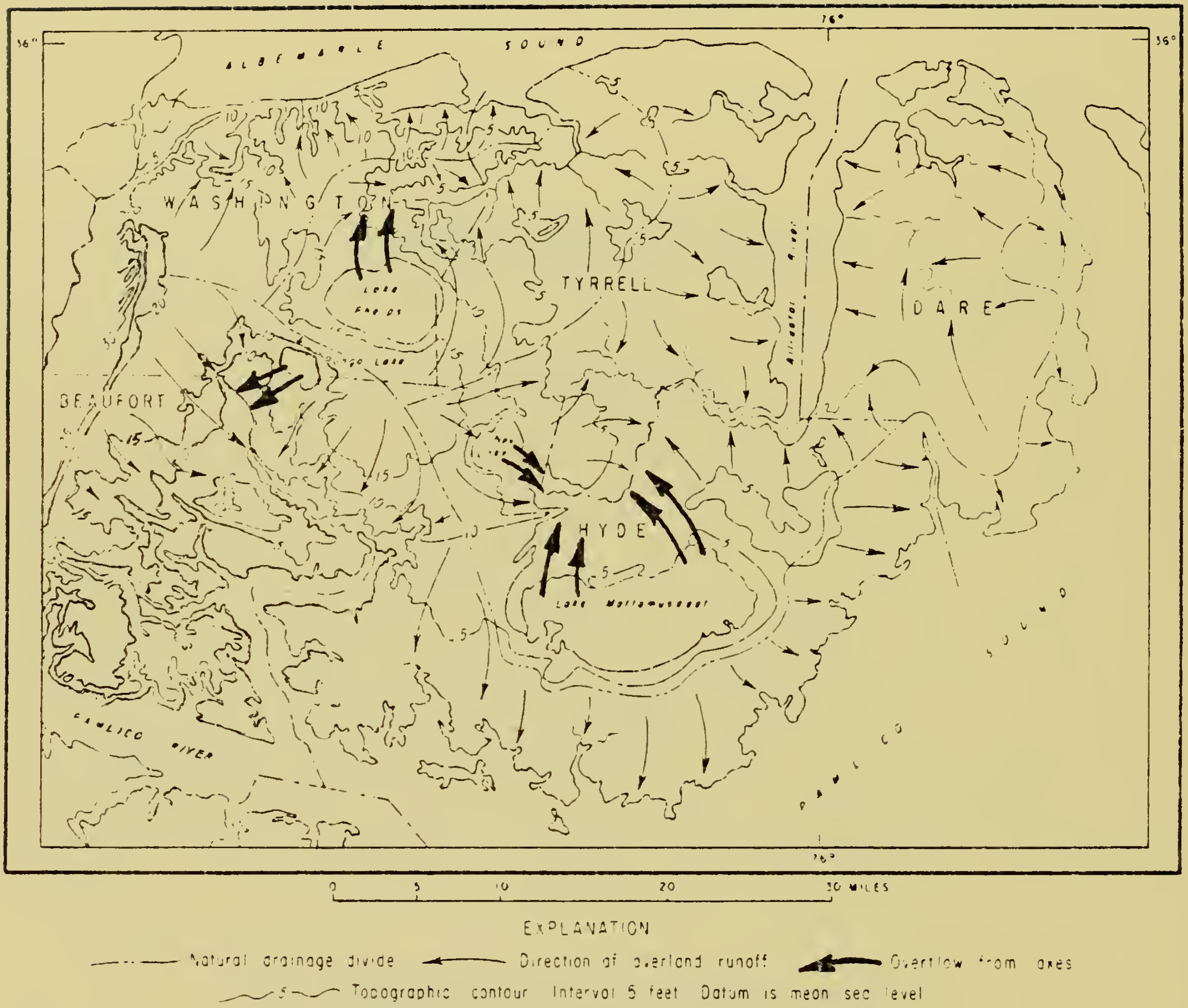


SUMMER AND FALL CONDITIONS



SEASONAL GROUNDWATER FLOW CONDITIONS IN ARTIFICIALLY DRAINED AREAS

Figure A.13



.--Paths taken by overland runoff.

Figure A.14

DISTRIBUTION OF RAINFALL INTENSITIES FOR VARIOUS RECURRENCE INTERVALS

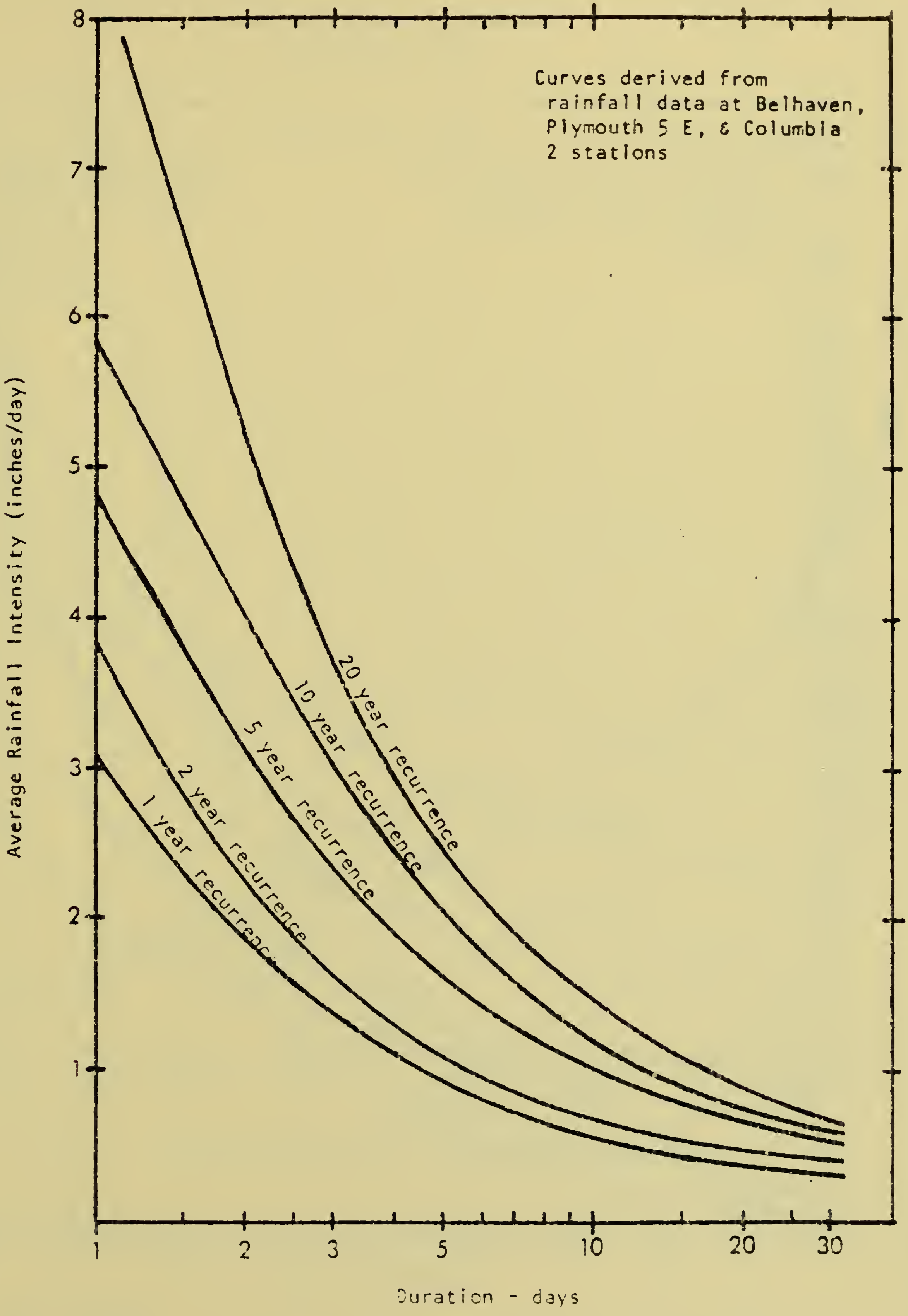


Figure A.15

ADEQUACY OF CONTROL RELEASES FROM LAKE PHELPS

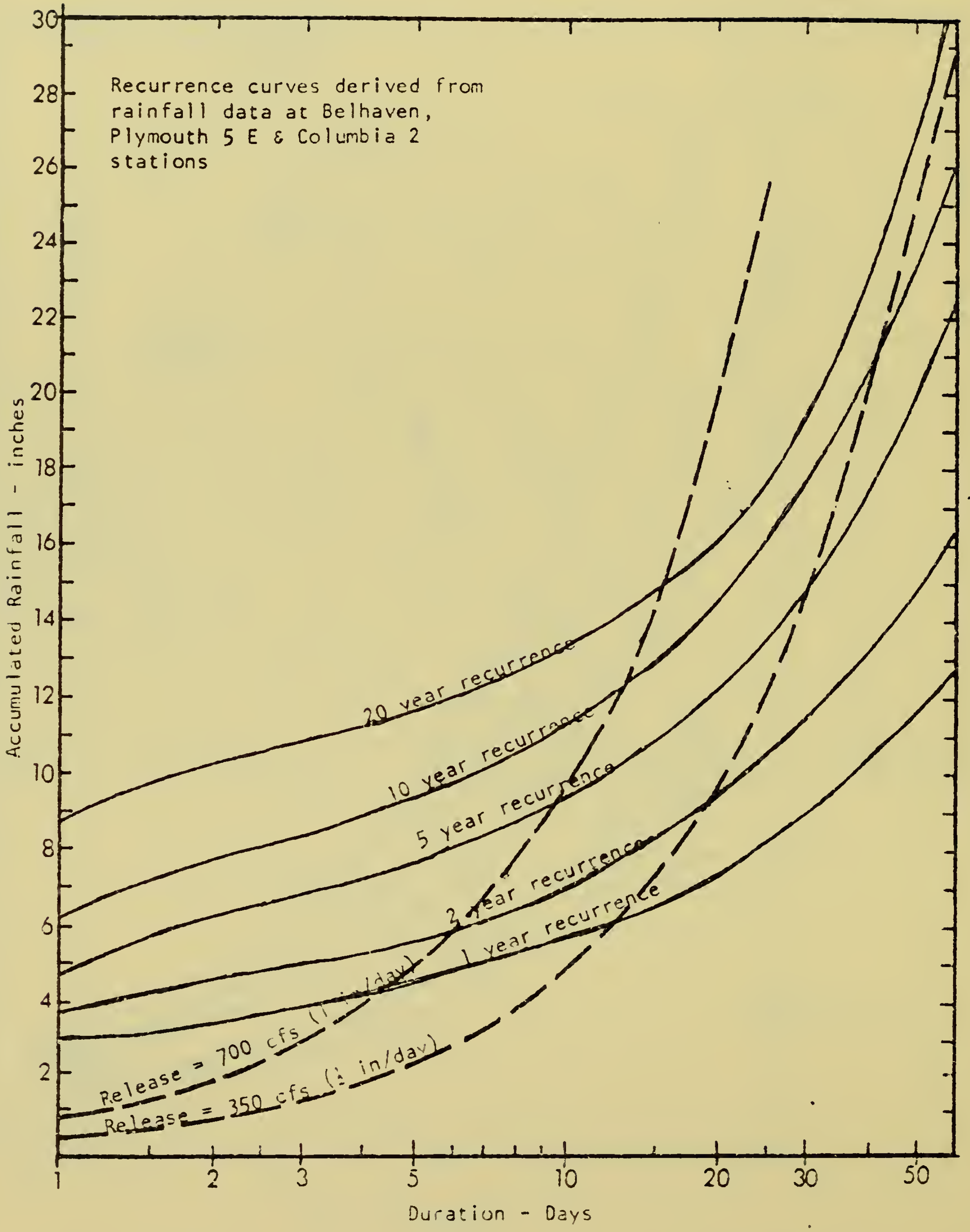
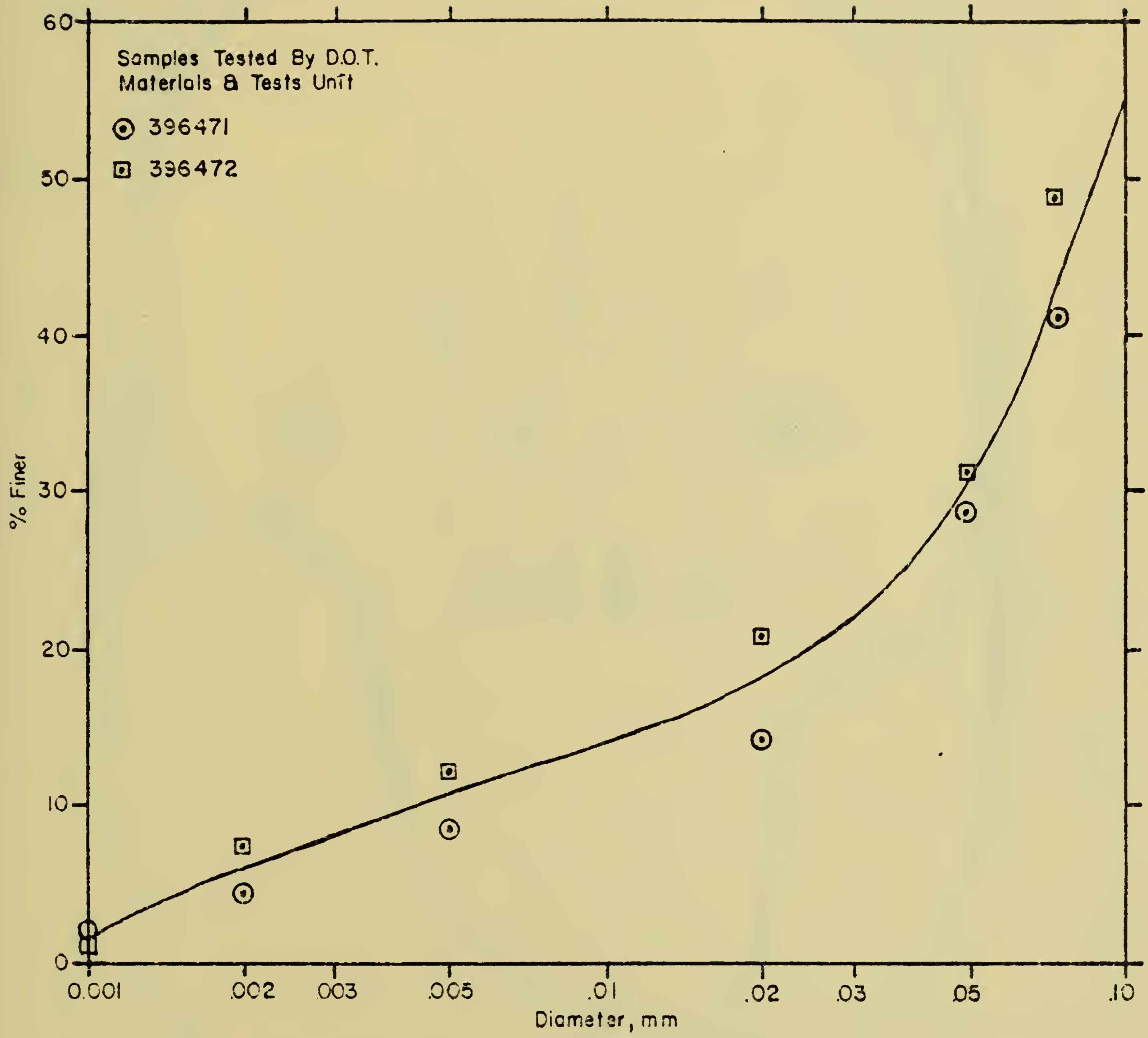


Figure A.16



DISTRIBUTION CURVE OF SILT IN BEE TREE CANAL

Figure A.17

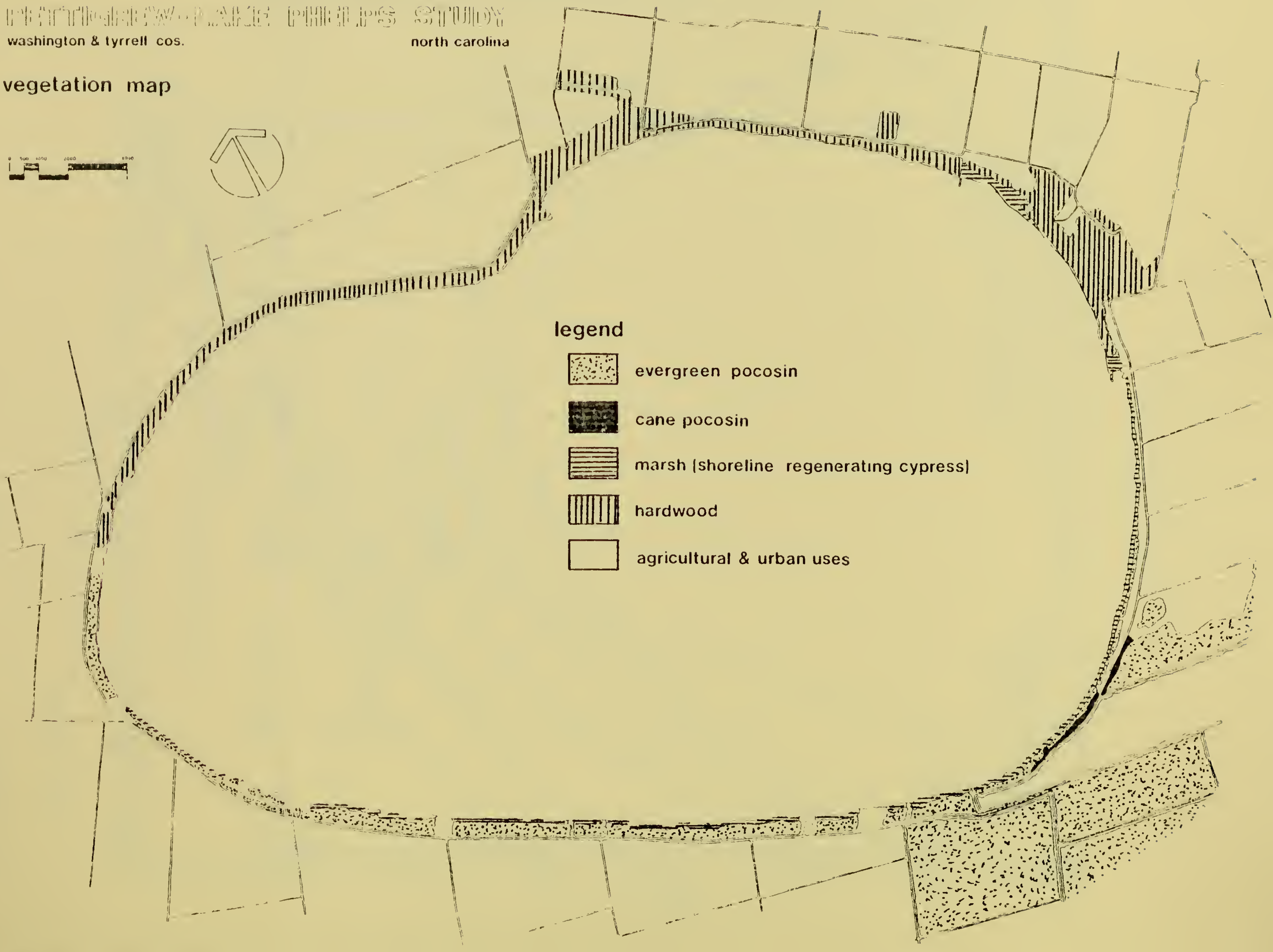

PETTIGREW-LAKE PHELPS STUDY
washington & tyrrell cos.
north carolina
vegetation map
0 500 1000 2000 4000
legend
evergreen pocosin
cane pocosin
marsh (shoreline regenerating cypress)
hardwood
agricultural & urban uses

Figure A.18

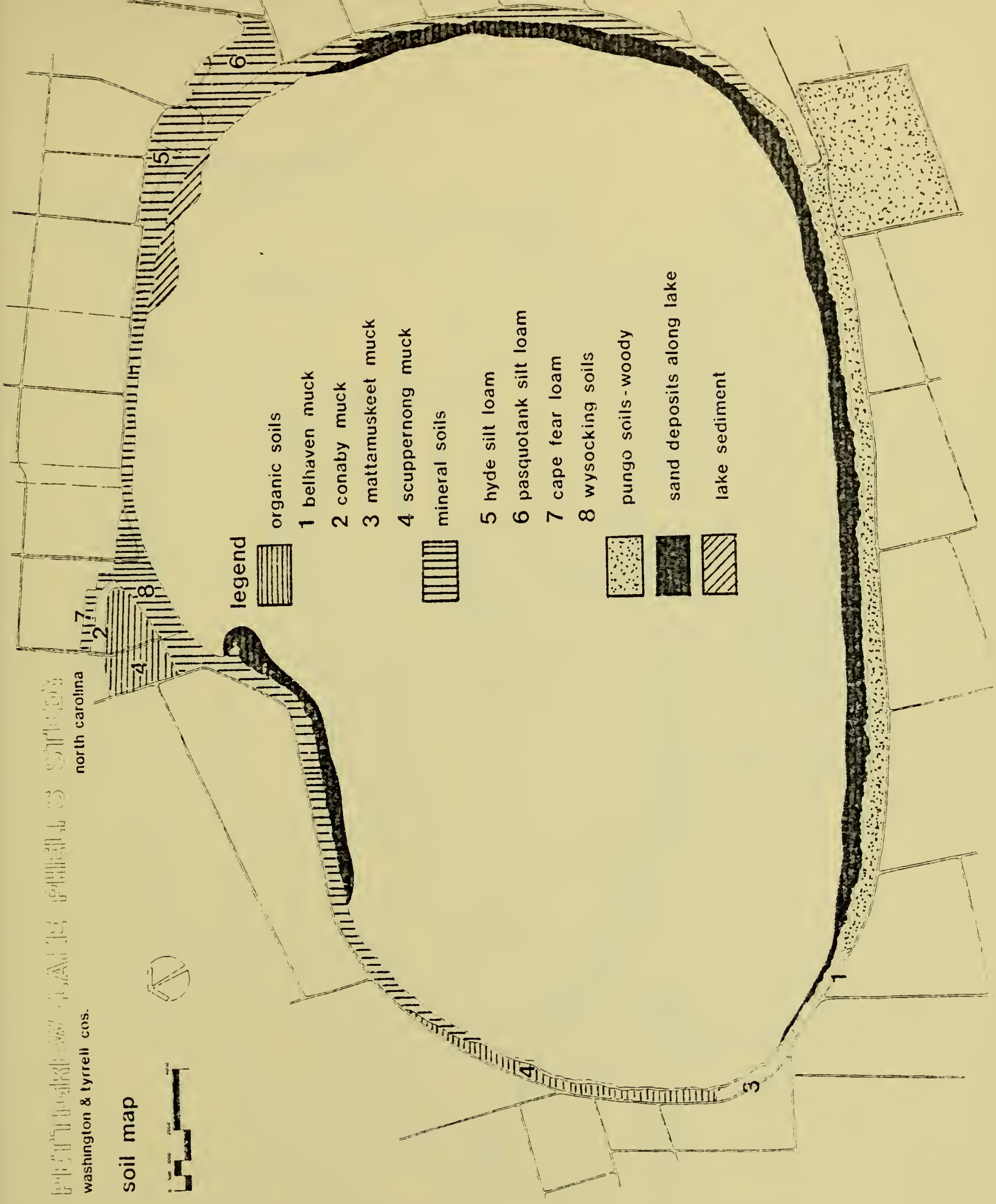

PETTIGREW STATE PARK
washington & tyrrell cos.
north carolina
soil map
legend
organic soils
1 belhaven muck
2 conaby muck
3 mattamuskeet muck
4 scuppernong muck
mineral soils
5 hyde silt loam
6 pasquotank silt loam
7 cape fear loam
8 wysocking soils
pungo soils-woody
sand deposits along lake
lake sediment
1
2
3
4
4
5
6
7
8
0
500
1000
2000
4000

Figure A.19

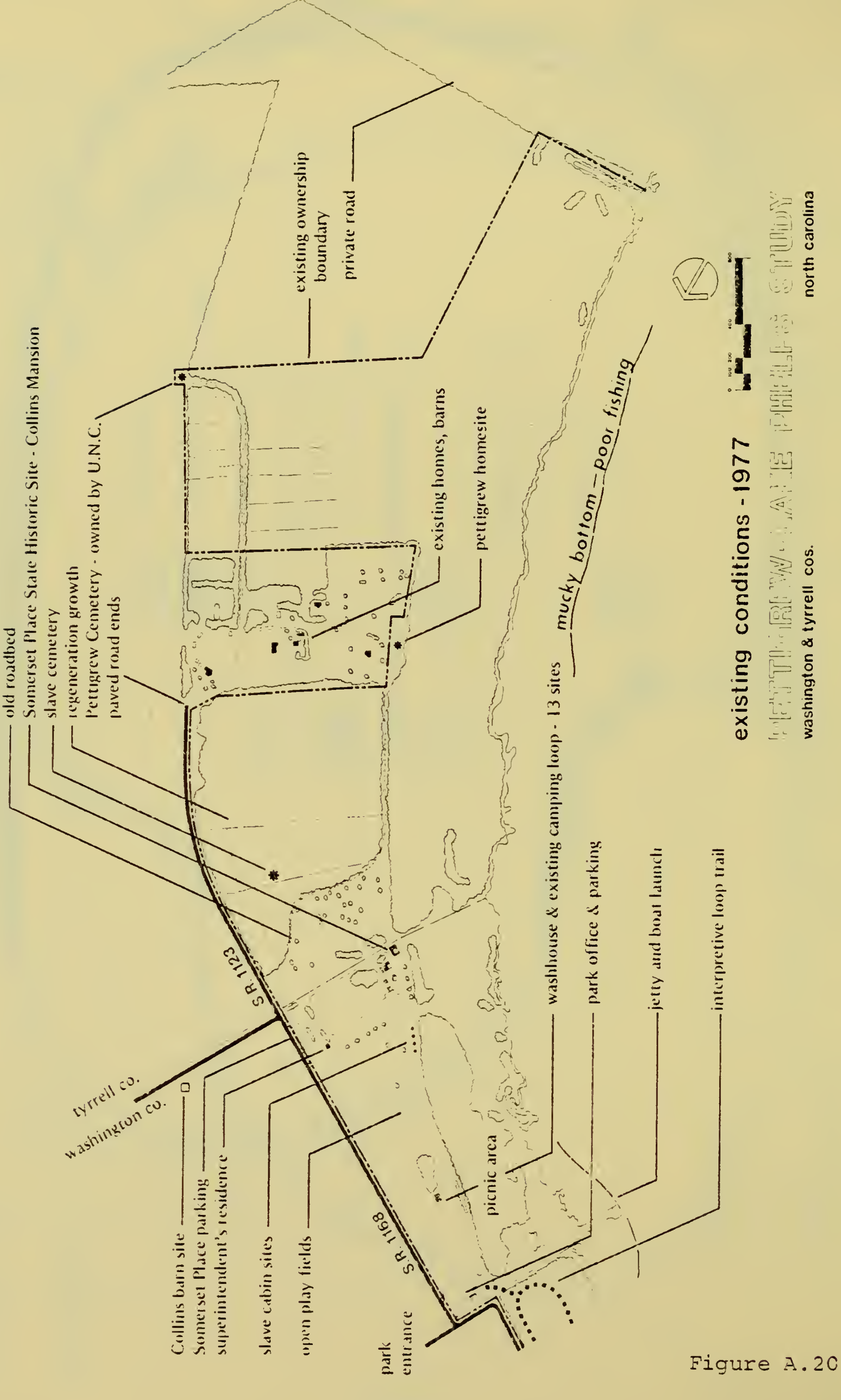

existing conditions - 1977
PETTIGREW LAKE PHELPS STUDY
washington & tyrrell cos.
north carolina
0 100 200 400 800
old roadbed
Somerset Place State Historic Site - Collins Mansion
slave cemetery
regeneration growth
Pettigrew Cemetery - owned by U.N.C.
paved road ends
existing ownership boundary
private road
existing homes, barns
pettigrew homesite
mucky bottom — poor fishing
washhouse & existing camping loop - 13 sites
park office & parking
jetty and boat launch
interpretive loop trail
picnic area
S.R. 1123
S.R. 1168
tyrrell co.
washington co.
Collins barn site
Somerset Place parking
superintendent's residence
slave cabin sites
open play fields
park entrance

Figure A.20

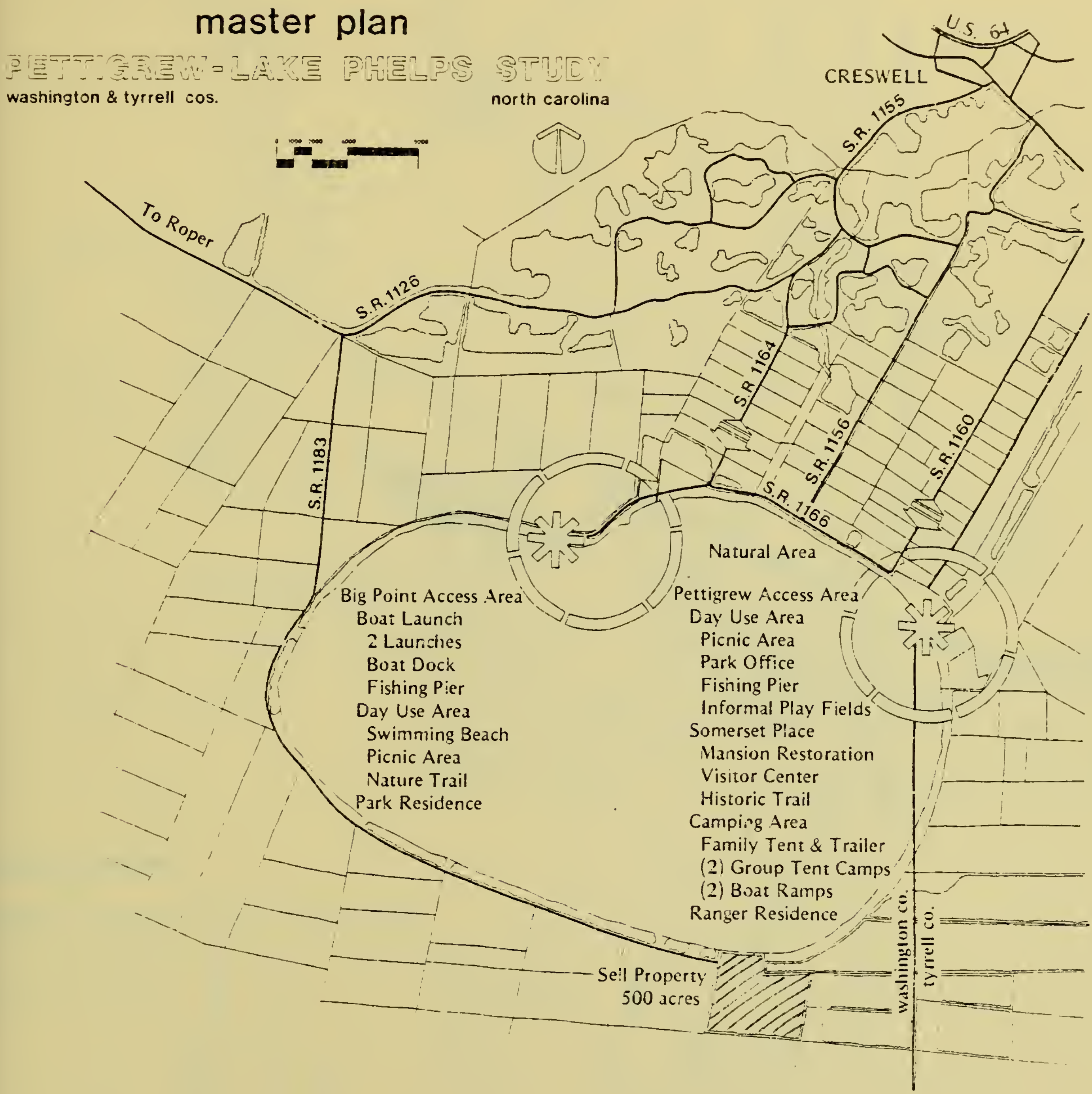

master plan
PETTIGREW-LAKE PHELPS STUDY
washington & tyrrell cos.
north carolina
U.S. 64
CRESWELL
S.R. 1155
To Roper
S.R. 1126
S.R. 1164
S.R. 1183
S.R. 1156
S.R. 1160
S.R. 1166
Natural Area
Big Point Access Area
Boat Launch
2 Launches
Boat Dock
Fishing Pier
Day Use Area
Swimming Beach
Picnic Area
Nature Trail
Park Residence
Pettigrew Access Area
Day Use Area
Picnic Area
Park Office
Fishing Pier
Informal Play Fields
Somerset Place
Mansion Restoration
Visitor Center
Historic Trail
Camping Area
Family Tent & Trailer
(2) Group Tent Camps
(2) Boat Ramps
Ranger Residence
Sell Property
500 acres
washington co.
tyrrell co.

Figure A.21

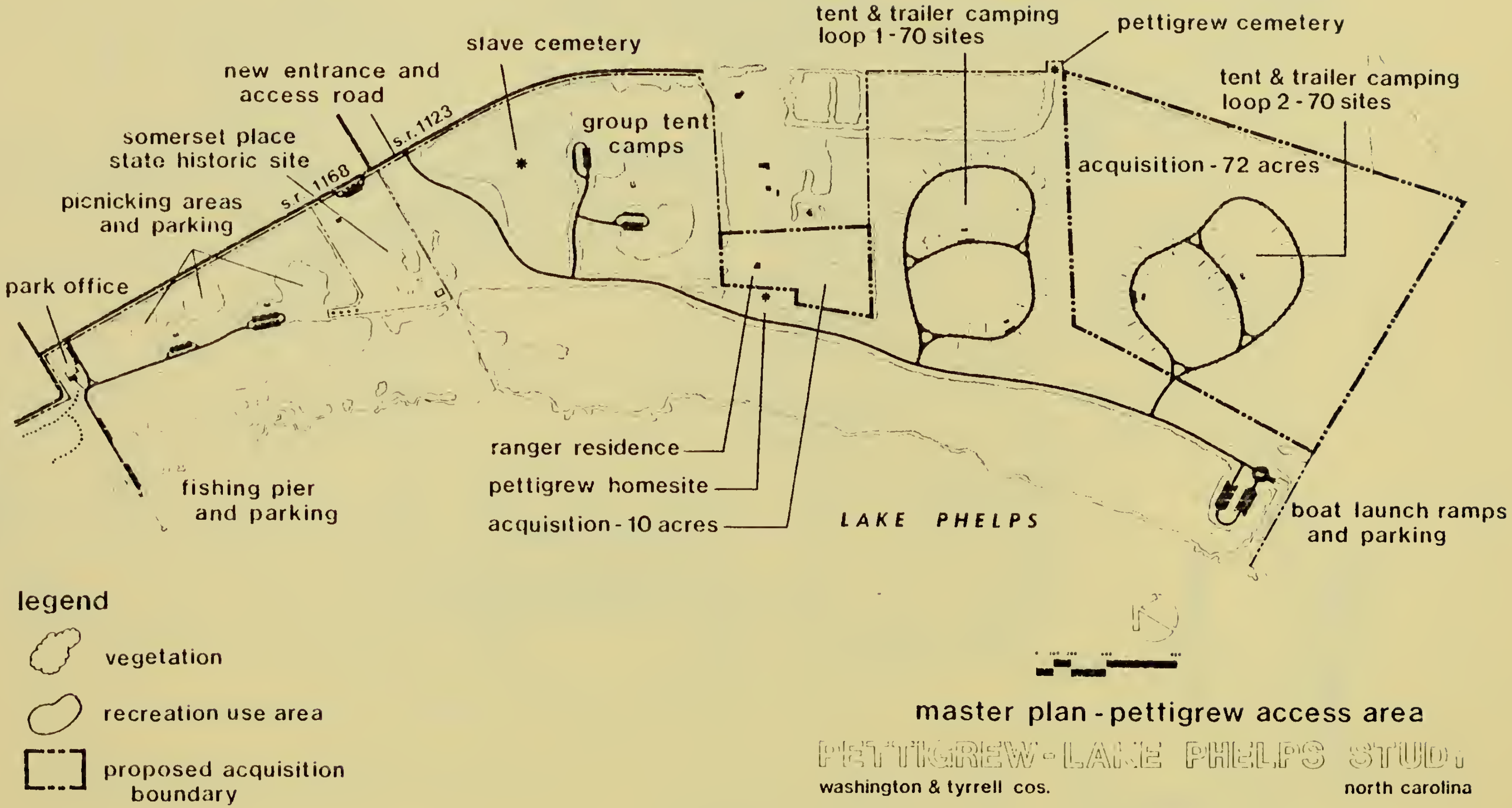
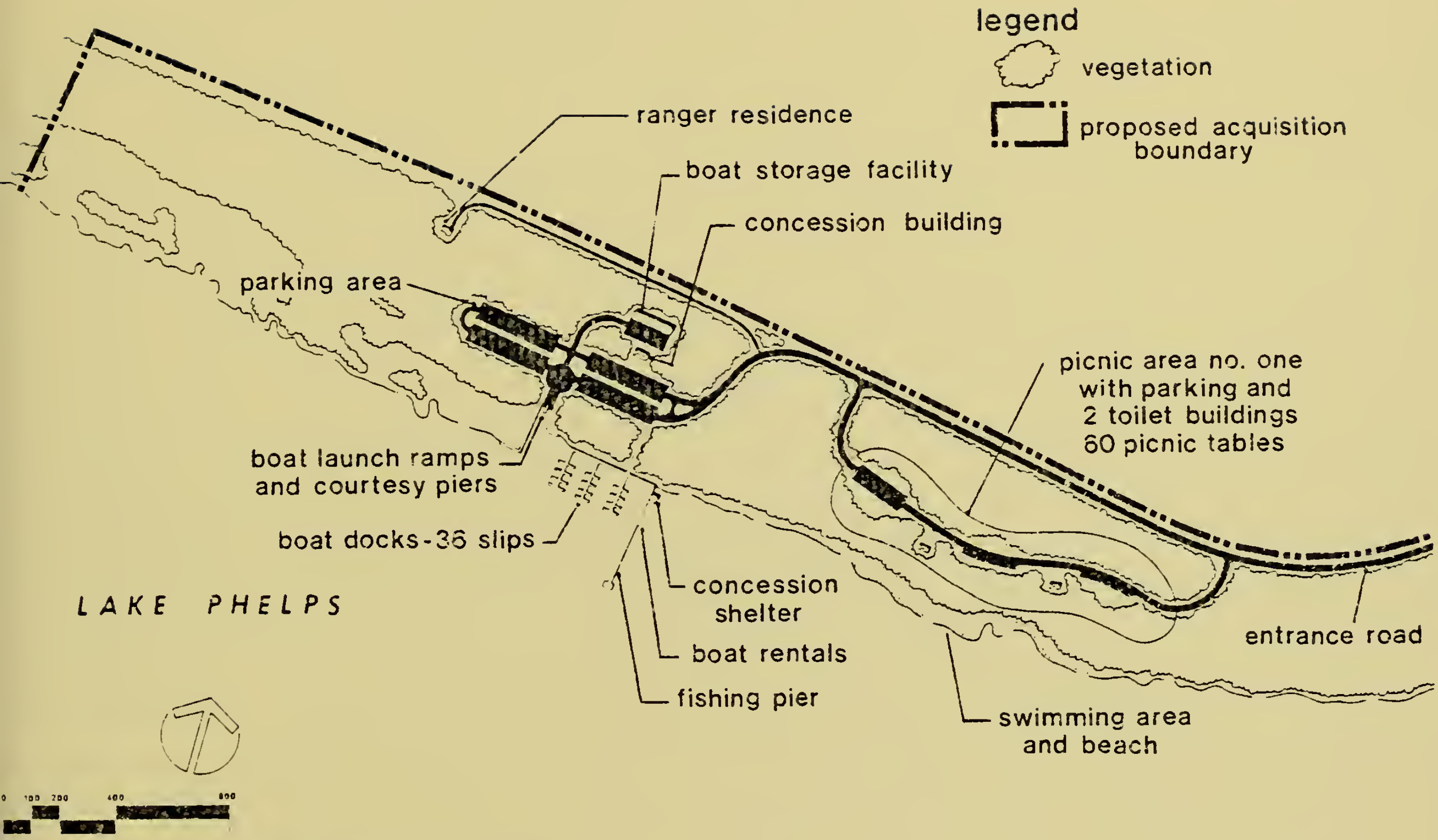

new entrance and access road
somerset place state historic site
picnicking areas and parking
park office
slave cemetery
group tent camps
s.r. 1123
s.r. 1168
tent & trailer camping loop 1 - 70 sites
pettigrew cemetery
tent & trailer camping loop 2 - 70 sites
acquisition - 72 acres
ranger residence
pettigrew homesite
acquisition - 10 acres
fishing pier and parking
LAKE PHELPS
boat launch ramps and parking
legend
vegetation
recreation use area
proposed acquisition boundary
master plan - pettigrew access area
PETTIGREW-LAKE PHELPS STUDY
washington & tyrrell cos.
north carolina

Figure A.22



naster plan-big point access area

ETTIGREW-LAKE PHELPS STUDY

vashington & tyrrell cos. north carolina

Figure A.23

APPENDIX

Tables

TABLE A.1. - RAINFALL DATA 1964 - 1977

COLUMBIA 2

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
1964	5.53	6.12	3.56	3.76	1.90	2.92	6.15	10.06	9.55	7.75	1.00	2.69	60.99
1965						NO	DATA						
1966	6.10	4.62	3.76	1.38	14.20	5.78	2.59	8.81	6.61	.89	1.53	5.57	61.84
1967	3.83	4.88	.87	1.83	2.18	2.24	16.29	11.04	3.70	2.64	2.41	4.05	55.96
1968						NO	DATA						
1969	2,74	3.52	6.50	6.47	3.22	3.86	9.85	6.67	3.97	2.00	6.04	4.03	58.87
1970	3.60	4.48	4.40	4.62	3.57	3.50	5.24	4.02	1.75	1.94	3.10	2.97	43.19
1971	3.92	3.82	5.54	2.75	4.16	1.88	7.52	8.36	9.02	11.60	2.06	.97	61.60
1972	4.02	3.76	3.61	1.63	4.53	2.71	5.59	3.50	3.26	2.32	5.96	2.94	43.83
1973						NO	DATA						
1974	3.59	7.54	5.60	3.50	4.94	6.49	6.78	12.49	2.29	2.24	1.17	3.82	60.45
1975	4.30	3.37	4.48	4.35	2.01	3.37	9.36	1.58	7.06	3.74	1.73	5.07	50.42
1976	2.19	1.57	1.65	1.10	5.36	5.74	6.21	3.47	3.90	3.30	2.90	4.66	42.05
1977	3.70	1.71	3.90	2.12	5.13	4.07	3.27	7.81	2.80	7.55	5.41	4.38	51.85
Average													53.73

Continued

TABLE A.1 - RAINFALL DATA 1964 - 1977 CONTINUATION

PLYMOUTH 5E

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
1964	5.10	5.90	3.72	2.23	.88	2.41	4.92	7.77	8.10	10.30	2.21	4.71	58.25
1965						NO	DATA						
1966	6.63	5.65	1.80	1.71	11.12	3.57	.77	10.93	4.83	.62	1.01	3.63	52.27
1967	2.25	4.57	.88	1.56	2.37	1.74	11.24	11.48	5.43	1.18	2.65	4.64	49.99
1968						NO	DATA						
1969	2.73	2.97	4.90	4.49	1.56	3.17	6.49	6.21	4.16	2.01	5.21	4.79	48.69
1970	2.24	4.10	3.19	3.22	1.98	2.48	7.20	4.15	1.40	1.35	1.59	3.51	36.41
1971	4.24	6.04	5.89	2.00	5.01	4.76	6.68	6.77	6.86	11.52	2.01	1.10	62.88
1972	4.63	4.06	5.24	1.97	7.48	3.09	6.00	4.53	2.18	5.55	4.63	3.35	52.71
1973						NO	DATA						
1974	4.35	4.51	5.31	4.27	6.12	3.44	5.64	7.66	3.43	2.10	1.39	3.19	51.41
1975	4.96	3.99	4.76	4.33	2.72	2.36	11.34	0.33	6.85	3.40	1.31	5.04	51.39
1976	3.57	1.87	3.69	1.11	6.61	6.76	7.23	2.02	4.47	2.34	2.62	4.01	46.30
1977	3.53	1.82	4.14	3.06	7.02	4.71	4.29	8.05	3.66	7.87	6.64	5.39	60.18
Average													55.69

Continued

TABLE A.1 - RAINFALL DATA 1964 - 1977 CONTINUATION

BELHAVEN

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year	Three Station Year Average
1964	5.73	5.85	3.10	3.74	1.42	5.10	6.94	5.28	10.00	10.49	1.53	3.28	62.46	60.57
1965						NO	DATA							
1966	6.92	4.57	5.53	1.92	13.23	3.57	4.91	10.94	2.74	1.04	.82	4.05	60.24	58.12
1967	3.75	5.10	1.33	2.18	3.05	.72	6.95	7.15	3.17	1.21	3.77	5.76	44.14	50.03
1968						NO	DATA							
1969	2.84	2.69	5.43	4.52	1.61	10.62	13.0	5.06	2.85	1.16	5.19	3.31	58.28	55.28
1970	2.69	3.39	3.75	1.84	3.54	1.57	9.45	2.23	3.75	1.52	3.53	2.71	39.97	39.86
1971	4.39	3.53	4.16	2.74	4.46	3.62	8.93	6.12	8.12	17.17	2.95	1.68	67.87	64.12
1972	5.85	4.13	4.00	2.09	6.92	3.67	8.58	4.62	3.91	6.52	5.61	2.53	58.43	51.66
1973						NO	DATA							
1974	3.04	3.50	4.01	4.11	7.43	3.80	1.99	8.19	3.31	2.40	1.51	4.13	47.42	53.09
1975	4.97	4.47	3.57	4.50	7.13	6.33	6.00	1.35	8.41	3.66	1.76	5.26	57.41	53.07
1976	3.11	1.47	2.54	1.31	8.10	5.70	3.51	3.05	6.09	2.89	3.23	4.39	45.39	44.58
1977	2.69	1.29	4.96	1.68	7.36	3.03	3.28	5.32	4.46	7.35	4.41	4.54	50.37	54.13
Average													53.82	
Three Station Average	3.96	4.13	3.99	3.04	4.65	3.87	7.17	7.07	4.90	4.18	3.03	3.74		53.14

Table A.2 - Chemical quality of precipitation and of Lake Phelps.

Constituent or characteristic	Precipitation	Lake Phelps (5-16-74)
Silica (SiO_2) (mg/l)......		0.3
Calcium (Ca) (mg/l).......	0.4	4.0
Magnesium (Mg) (mg/l).....	.2	1.4
Sodium (Na) (mg/l)........	.9	5.4
Potassium (K) (mg/l)......	.1	2
Bicarbonate (HCO_3) (mg/l).		2
Sulfate (SO_4) (mg/l)......	1.9	15
Chloride (Cl) mg/l).......	1.1	9.5
Fluoride (F) (mg/l).......		.0
Nitrite + nitrate as Nitrogen (NO_2 + NO_3 as N) (mg/l)..	.08[1/]	.10
Dissolved Solids (Residue at180 C) (mg/l).........		54
Sum of mineral constituents (mg/l)..................		38
Hardness (Ca, Mg) (mg/l)...		16
Noncarbonate hardness (mg/l).................		14
Specific conductance (micro-mhos)...........		75
pH (units).................	5.0	6.0
Color (Platinum-Cobalt (units).................		3

[1/] Nitrate as nitrogen

TABLE A.3 - MONTHLY MODELED LAKE LEVELS - 1955 - 1976 - 11.50 msl

TARGET ELEVATION

Lake Level Feet Above msl

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1955	11.00	11.08	11.17	11.07	10.90	11.03	11.05	11.43	11.71	11.42	11.32	11.31
1956	11.36	11.48	11.47	11.42	11.29	11.08	11.28	11.47	11.43	11.43	11.45	11.35
1957	11.33	11.48	11.50	11.40	11.27	11.12	10.78	10.53	10.47	10.78	10.86	11.26
1958	11.47	11.48	11.49	11.45	11.42	11.28	11.20	11.22	11.36	11.47	11.41	11.39
1959	11.46	11.48	11.49	11.49	11.31	11.12	11.31	11.35	11.28	11.22	11.23	11.32
1960	11.50	11.76	11.47	11.38	11.23	11.24	11.25	11.44	11.65	11.43	11.34	11.33
1961	11.42	11.54	11.47	11.46	11.49	11.50	11.46	11.39	11.47	11.42	11.24	11.40
1962	11.51	11.47	11.49	11.44	11.26	11.33	11.67	11.23	11.23	11.24	11.27	11.44
1963	11.52	11.49	11.46	11.34	11.20	11.40	11.17	11.22	11.15	11.12	11.18	11.44
1964	11.51	11.50	11.47	11.41	11.13	10.92	10.74	10.83	11.39	11.64	11.37	11.43
1965	11.47	11.50	11.47	11.33	11.16	11.34	11.59	11.44	11.26	11.18	10.99	10.88
1966	11.03	11.33	11.45	11.23	11.35	11.47	11.17	11.30	11.42	11.36	11.16	11.17
1967	11.38	11.45	11.39	11.18	10.97	10.73	10.87	11.33	11.48	11.26	11.12	11.35
1968	11.50	11.39	11.45	11.44	11.45	11.36	11.30	11.16	10.99	10.86	10.97	10.99
1969	11.04	11.24	11.35	11.40	11.29	11.14	11.26	11.42	11.30	11.22	11.44	11.46
1970	11.45	11.50	11.43	11.42	11.29	11.01	11.08	11.06	10.88	10.69	10.64	10.63
1971	10.83	11.15	11.46	11.40	11.29	11.23	11.35	11.37	11.27	11.29	11.43	11.49
1972	11.49	11.49	11.47	11.40	11.45	11.41	11.35	11.37	11.27	11.29	11.43	11.49
1973	11.49	11.40	11.48	11.46	11.42	11.32	11.42	11.43	11.30	11.19	11.05	11.29
1974	11.49	11.50	11.45	11.48	11.38	11.37	11.22	11.45	11.42	11.26	11.15	11.22
1975	11.42	11.48	11.48	11.46	11.31	11.12	11.36	11.22	11.16	11.25	11.21	11.30
1976	11.49	11.45	11.40	11.31	11.22	11.46	11.44	11.36	11.23	11.17	11.13	11.30
Total Average	11.37	11.44	11.44	11.38	11.28	11.23	11.24	11.27	11.27	11.24	11.20	11.28

Table A.4 - DEPTH OF SILTATION IN CANAL ENTRANCE

Canal	Depth of Existing Siltation - inches		
	@ Gate	@ ½ to Lake	@ Lake
Bee Tree	42	72	84
Magnolia	26	20	28
Mocassin	6	72	72
Thirty Foot	6	58	50
Transportation	55	58	71
Western	38	55	60

TABLE A.5 PETTIGREW STATE PARK VEGETATION

Zenobia	Zenobia nuda
Bamboo	Somilax laurifolia
Titi	Cyrilla racemiflora
Chainfern	Woodwardia virginica
Fetterbush	Lyonia lucida
Loblolly Bay	Gordonia lasianthus
Dangle Berry	Gaylussacia frondosa
Sweet Gallberry	Ilex coriacea
Inkberry	Ilex glabra
Sweet Pepperbush	Clethra alnifolia
Sweet Bay	Magnolia virginiana
Sheep-Kill	Kalmia carolina
Cane	Arundinaria tecta
Leather-Leaf	Chamaedaphne calyculata
Virginia Willow	Itea virginica
Blueberry	Vaccinium virgatum
Highbush Blueberry	Vaccinium corymbosum
Red Chokeberry	Aronia arbutifolia
Male Blueberry	Lyonia foliosiflora
Dwarf Huckleberry	Gaylussacia dumosa
Black Gum	Nyssa biflora
Swamp Honeysuckle	Rhododendron serrulatum
Haw	Viburnum nudum
Leucothoe	Leucothoe axillaris
Wax Myrtle	Myrica cerifera
Bald Cypress	Taxodium distichum
Sweet Gum	Liquidambar styraciflua
Red Maple	Acer rubrum
Black Gum	Nyssa sylvatica biflora
Yellow Popular	Liriodendron tulipifera
Water Hickory	Carya aquatica
Shagbark Hiclory	Carya ovata
Green Ash	Fraxinus pennsylvanica
Sycamore	Platanus occidentalis
Swamp Chestnut Oak	Quercus michauxii
Pawpaw	Asimina triloba
Hackberry	Celtis laevigata
Holly	Ilex opaca
Sweet Bay	Magnolia virginiana
Red Mulberry	Morus rubra
Carolina Laurel Cherry	Prunus caroliniana
Swamp Willow	Salix caroliniana
American Elm	Ulmus americana
French Mulberry	Callicarpa americana
Button Bush	Cephalanthus occidentalis
Sweet Pepperbush	Clethra alnifolia var. alnifolia
Virginia Willow	Itea virginica
Spice Bush	Lindera benzoin
Red Bay	Persea borbonia

Swamp Rose	Rosa palustris
Blackberry	Rubus sp.
Elderberry	Sambucus canadensis
Hercules' Club	Xanthoxylum clavaherculis

Pepper Vine	Ampelopsis arborea
Vine	Berchemia scandens
Climbing Hydrangea	Decumaria barbara
Japanese Honeysuckle	Lonicera japonica
Coral Honeysuckle	Lonicera sempervirens
Creeping Cucumber	Melothria pendula
Climbing Hempweed	Mikania scandens
Virginia Creeper	Parthenocissus quinquefolia
Poison Ivy	Rhus radicans
Poison Oak	Rhus toxicodendron
Green Brier	Somilax glauca
Catbrier	Somilax rotundifolia
Muscadine	Vitis rotundifolia

Jack-in-the-Pulpit	Arisaema triphyllum
False Nettle	Boehmeria cylindrica
Water Hemlock	Cicuta maculata
Dayflower	Commelina communis
Queen Anne's Lace	Daucus carota
Indian Strawberry	Duchesnea indica
Elephant's Foot	Elephantopus carolinianus
Fleabane	Erigeron sp.
Thoroughwort	Eupatorium sp.
Bedstraw	Galium aparine
Avens	Geum canadense

TABLE A.6 - MID-WINTER WATERFLOWL INVENTORY, LAKE PHELPS, NORTH CAROLINA

1966 THROUGH 1974

SPECIES	1966	1967	1968	1969	1970	1971	1972	1973	1974
Mallard	30	20	65	-	70	10	-	10	50
Black Duck	400	170	170	100	50	185	200	60	50
American Widgeon	-	30	-	-	-	-	-	10	100
Green-Winged Teal	-	-	20	30	-	-	-	-	-
Pintail	-	50	50	-	100	-	-	-	-
Wood Duck	10	-	-	-	-	-	-	-	-
Canvas-Back	-	-	30	-	-	-	-	-	-
Lesser Scaup	-	-	60	-	50	25	50	-	-
Ring-Necked Duck	-	-	30	-	100	-	-	20	-
Buffle-Head	30	14	-	-	20	-	-	-	-
Ruddy Duck	400	-	20	100	200	125	20	-	-
Mergansers	10	-	-	50	-	-	-	200	-
Unidentified Ducks	50	-	-	300	-	50	-	-	-
TOTAL DUCKS	930	284	445	580	590	395	270	300	200
Canada Goose	1400	1100	440	650	600	1300	220	650	1200
American Coot	-	-	-	-	-	-	100	170	-
TOTAL WATERFOWL	2330	1384	885	1230	1190	1695	860	1120	1400

TABLE A. 7 - POSSIBLY OCCURRING WILDLIFE

Bee Tree Canal

Gamefish:

White Perch	Roccus americanus
Yellow Perch	Perca flavescens
Bluegill	Lepomis macrochirus
Black Crappie	Pomoxis nigromaculatus
Warmouth	Chaenobryttus gulosus
Largemouth Bass	Micropterus salmoides
Pumpkinseed	Lepomis gibbosus

Non-Gamefish

Blueback Herring	Alosa aestivalis
Golden Shiner	Notemigonus chrysoleucas
Tadpole Madtom	Noturus gyrinus
Alewife	Alosa pseudoharengus
Channel Catfish	Ictalurus punctatus
Johnny Darter	Etheostoma nigrum
Gizzard Shad	Dorosoma cepedianum
Banded Sunfish	Enneacanthus obesus
Pirate Perch	Aphredoderus sayanus
Atlantic Menhaden	Brevoortia tyrranus
Scaleyhead Darter	Etheostoma barratti
Longnose Gar	Lepisosteus osseus
Silvery Minnow	Hybognathus nuchalis
Brown Bullhead	Ictalurus nebulosus
Banded Killifish	Fundulus diaphanus
Mosquito Fish	Gambusia affinis
American Eel	Anguilla rostrata

Fish-Food Organisms & Number Found:

Flies	Diptera
Caddis Flies	Trichoptera
Beetles	Coleoptera
Worms	Oligochaeta
Leeches	Hirudinea

Moccasin Canal:

Gamefish:

Pumpkinseed	Lepomis gibbosus
Bluegill	Lepomis macrochirus
Warmouth	Chaeonobryttus gulosus
Yellow Perch	Perca flavescens
Redfin Pickerel	Esox americanus americanus
Largemouth Bass	Micropterus salmoides
Chain Pickerel	Esox niger

Non-Gamefish

Yellow Bullhead	Ictalurus natalis
Brown Bullhead	Ictalurus nebulosus
Lake Chubsucker	Erimyaon succetta
Banded Sunfish	Enneacanthus obesus
Tadpole Madtom	Noturus gyrinus
Bluespotted Sunfish	Enneacanthus gloriosus
Mosquito Fish	Gambusia affinis
Pirate Perch	Aphredoderus sayanus
Scalyhead Darter	Etheostoma barratti
Golden Shiner	Notemigonus chrysoleucas
Johnny Darter	Etheostoma nigrum
Bowfin	Amia calva
Satinfish Shiner	Notropis analostanus
Sawcheek Darter	Etheostoma serriferum
American Eel	Anguilla rostrata

Fish-Food Organisms & Number Found

Flies	Diptera
Beetles	Coleoptera
Dragon flies and Damsel flies	Odonata
Leeches	Hirundinea
Slugs & Snails	Gastropoda
True Bugs	Hemiptera
Flatworms	Platyhelminthes
May flies	Ephemeroptera
Worms	Oligochaeta
Mussels	Pelecypoda
Amphipods	Amphipoda
Lacewings	Neuroptera
Waterscorpions	Hydracarina

Lake Phelps Fish

Longnose Gar	Lepisosteus osseus
Bowfin	Amia calva
American Eel	Anguilla rostrata
Gizzard Shad	Dorosoma cepedianim
Redfin Pickerel	Esox americanus
Chain Pickerel	Esox niger
Golden Shiner	Notemigonus chrysoleucas
Satinfish Shiner	Notropis analostanus
Brown Bullhead	Ictalurus nebulosus
Tadpole Madtom	Noturus gyrinus
Waccamaw Killifish	Fundulus cf. waccamensis
Mosquitofish	Gambusia affinis
Tidewater Silverside	Menidia berylliana*
White Perch	Morone americana*
Bluespotted Sunfish	Enneacanthus gloriosus
Warmouth	Enneacanthus obesus
Pumpkinseed	Lepomis gulosus

Bluegill	Lepomis gibbosus
Largemouth Bass	Micropterus salmoides
Swamp Darter	Etheostoma fusiforme*
Johnny Darter	Etheostoma nigrum
Yellow Perch	Perca flavescens

Washington County

Amphibians:

Southern Cricket Frog	Acris gryllus
Green treefrog	Hyla cinerea
Bullfrog	Rana catesbiana
Green Frog	Rana clamitans
Carpenter Frog	Rana virgatipes
Oak Toad	Bufo quercicus
American Toad	Bufo terrestris
Marble Salamander	Ambystoma opacum
Dusky Salamander	Desmognathus fuscus
Slimy Salamander	Plethodon glutinosus

Reptiles

Spotted Turtle	Clemmys guttata
Musk Turtle	Kinosternon subrubrum
Stinkpot	Sternotherus odoratus
Box Turtle	Terrapene carolina
Green Anole	Anolis carolinensis
Five-Lined Skink	Eumeces fasciatus
Broadheaded Skink	Eumeces laticeps
Copperhead	Agkistrodon contortrix
Worm Snake	Carphophis amoenus atricaudatus
Canebrake Rattlesnake	Crottalus horridus
Ringneck Snake	Diadophis punctatus

Tyrrell County

Amphibians:

Green Treefrog	Hyla cinerea
Pinewoods Treefrog	Hyla femoralis
Squirrel Treefrog	Hyla squirrella
Least Grass Frog	Limnaoedus ocularis
Bullfrog	Rana catesbiana
Green Frog	Rana clamitans
Leopard Frog	Rana pipiens
Fowler's Toad	Bufo fowleri
Oak Toad	Bufo quercicus
American Toad	Bufo terrestris
Eastern Narrow-Mouthed Toad	Gastrophryne carolinenesis
Red-spotted Newt	Notophthalamus viridescens
Slimmy Salamander	Plethodon glutinosus
Many-Lined Salamander	Stereochilus marginatus

Reptiles:

River Cooter	Chrysemys concinna
Spotted Turtle	Clemmys guttata
Stinkpot	Kinosternon subrubrum
Southeastern Five-Lined Skink	Eumeces inexpectatus
Ground Skink	Lygosoma laterale
Black Snake	Coluber constrictor
Ringneck Snake	Diadophis punctatus
Corn Snake	Elaphe guttata
Rat Snake	Elaphe obsoleta
Mud Snake	Farancia abacura
Scarlet Kingsnake	Lampropeltis triangulum
Red-Bellied Water Snake	Natrix erythrogaster
Banded Water Snake	Natrix fasciata
Glossy Water Snake	Regina rigida
Carolina Swamp Snake	Seminatrix pygaea paludis
Brown Snake	Storeria dekayi
Eastern Ribbon Snake	Thamnophis sauritus
Eastern Garter Snake	Thamnophis sirtalis

TABLE A.8 - AMPHIBIANS AND REPTILES OF FIRST COLONY FARMS

Common name	Scientific name	Collected in FCF area
REPTILES		
Alligator		
American alligator	Alligator mississippiensis	See Comments
Turtles		
Common snapping turtle	Chelydra serpentina serpentina	X
Stinkpot	Sternotherus odoratus	X
Eastern mud turtle	Kinosternon subrubrum subrubrum	X
Spotted turtle	Clemmys guttata	X*
Eastern box turtle	Terrapene carolina carolina	X*
Northern diamondback terrapin	Malaclemys terrapin terrapin	X
Carolina diamondback terrapin	Malaclemys terrapin centrata	X
Yellow-bellied turtle	Chrysemys scripta scripta	X
River Cooter	Chrysemys concinna concinna	X
Florida Cooter	Chrysemys floridana floridana	X
Red-bellied turtle	Chrysemys rubiventris	X
Eastern painted turtle	Chrysemys picta picta	X
Lizards		
Green anole	Anolis carolinensis carolinensis	X
Northern fence lizard	Sceloporus undulatus hyacinthinus	
Six-lined racerunner	Cnemidophorus sexlineatus sexlineatus	
Ground skink	Leiolopisma laterale	X
Five-line skink	Eumeces fasciatus	X
Broad-headed skink	Eumeces laticeps	X
Southeastern five-lined skink	Eumeces inexpectatus	X*
Eastern glass lizard	Ophisaurus ventralis	X
Eastern slender glass lizard	Ophisaurus attenuatus longicaudus	
Snakes		
Brown water snake	Natrix taxispilota	X*
Red-bellied water snake	Natrix erythrogaster erythrogaster	X
Northern water snake	Natrix sipedon sipedon	X
Carolina salt marsh snake (Outer Banks water snake)	Natrix sipedon williamengelsi	X

Banded water snake	Natrix fasciata fasciata	X*
Eastern glossy water snake	Natrix rigida rigida	X
Black swamp snake	Seminatrix pygaea	X
Northern brown snake	Storeria dekayi dekayi	X
Midland brown snake	Storeria dekayi wrightorum	X
Northern red-bellied snake	Storeria occipitomaculata occipitomaculata	X
Eastern garter snake	Thamnophis sirtalis sirtalis	X
Eastern ribbon snake	Thamnophis sauritus sauritus	X
Eastern earth snake	Virginia valeriae valeriae	
Routh earth snake	Virginia striatula	X
Eastern Hognose snake	Heterodon platyrhinas	X
Southern ringneck snake	Diadophis punctatus punctatus	X
Eastern worm snake	Carphophis amoenus amoenus	X
Pine woods snake	Rhadinaea flavilata	
Eastern mud snake	Farancia abacura abacura	X
Rainbow snake	Farancia erytrogramma	X
Northern black racer	Coluber constictor constrictor	X*
Routh green snake	Opheodrys aestivus	X
Corn snake	Elaphe guttata guttata	X
Rat snake	Elaphe obsoleta	X
Eastern kingsnake	Lampropeltis getulus getulus	X
Eastern milk snake	Lampropeltis triangulum triangulum	X
Scarlet kingsnake	Lampropeltis triangulum elapsoides	X
Mole snake	Lampropeltis calligaster rhombomaculata	
Scarlet snake	Comophora coccinea	X
Southeastern crowned snake	Tantilla coronata	
Southern copperhead	Agkistrodon contortrix contortrix	X*
Northern copperhead	Agkistrodon contortrix mokasen	
Eastern cottonmouth	Agkistrodon piscivorus piscivorus	X
Carolina pygmy rattlesnake	Sistrurus miliarius miliarius	X
Canebrake rattlesnake	Crotalus horridus atricaudatus	X*

AMPHIBIANS

Salamanders

Dwarf waterdog	Nocturus punctatus	
Two-toed amphiuma	Amphiuma means	X*
Greater siren	Siren lacertina	X
Lesser siren	Siren intermedia	
Marbled salamander	Ambystoma opacum	X
Mabee's salamander	Ambystoma mabeei	
Spotted salamander	Ambystoma maculatum	
Eastern tiger salamander	Ambystoma tigrinum tigrinum	
Red-spotted newt	Notophthalmus viridescens viridescens	X
Southern dusky Salamander	Desmognathus auriculatus	X

Red-backed salamander	Plethodon cinereus cinereus	
Slimy salamander	Plethodon glutinosus glutinosus	X
Many-lined salamander	Stereochilus marginatus	X
Eastern mud salamander	Pseudotriton montanus montanus	X
Northern red salamander	Pseudotriton ruber ruber	
Souther two-lined salamander	Eurycea bislineata cirrigera	
Three-lined salamander	Eurycea longicauda guttolineata	
Dwarf Salamander	Eurycea quadridigitata	

Toads and Frogs

Eastern spadefoot	Scaphiopus holbrooki holbrooki	
Southern toad	Bufo terrestris	X*
Fowler's toad	Bufo woodhousei fowleri	X*
Oak toad	Bufo quercicus	X*
Southern cricket frog	Acris gryllus gryllus	X*
Northern spring peeper	Hyla crucifer crucifer	X
Green treefrog	Hyla cinerea	X*
Barking treefrog	Hyla gratiosa	
Pine woods treefrog	Hyla femoralis	X
Squirrel treefrog	Hyla squirella	X*
Gray treefrog	Hyla versicolor	X
Little grass frog	Limnaoedus ocularis	X
Brimley's chorus frog	Pseudacris brimleyi	X
Eastern narrow-mouthed toad	Gastrophryne carolinensis	X
Bullfrog	Rana catesbeiana	X
Carpenter frog	Rana virgatipes	X
Green frog	Rana clamitans melanota	X*
Southern leopard frog	Rana utricularia	X*
Pickerel frog	Rana palustris	X
Crawfish frog	Rana aerolata	

Appendix Credits

Figures

A.1, A.5, A.8, A.19, A.20, A.21, A.22, A.23	Schweitzer and Williams, 1977
A.2, A.4	NRCD-Task Force Report, 1977
A.3	USGS
A.6, A.7, A.8, A.9, A.10 A.12, A.13, A.14	Heath, 1975
A.11, A.15, A.16, A.17	Tang, 1979

Tables

A.1	USDC, NOAA, 1964-1977
A.2, A.6	Heath, 1975
A.3, A.4	Tang, 1979
A.5, A.7, A.8	Hazard, 1978

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